*** D R A F T ***

# "*TOP-DOWN*" BEST AVAILABLE CONTROL TECHNOLOGY

# GUIDANCE DOCUMENT

Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Management Division
Noncriteria Pollutants Program Branch
New Source Review Section

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# I. PURPOSE

This document describes the U.S. Environmental Protection Agency (EPA) guidance for performing analyses leading to determinations of best available control technology (BACT) under the prevention of significant air quality deterioration (PSD) program. This document supersedes prior EPA guidance documents, policies, and interpretations in this subject area which are inconsistent with its terms.

The BACT requirement is defined as:

> "an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR Parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results."

The requirement to conduct a BACT analysis and determination is set forth in section 165(a)(4) of the Clean Air Act, in federal regulations at 40 CFR 52.21(j), in regulations setting forth the requirements for State implementation plan approval of a State prevention of significant deterioration (PSD) program at 40 CFR 51.166(j), and in the SIP's of the various States at 40 CFR Part 52, Subpart A - Subpart FFF. Neither this guidance document in particular nor EPA's policies regarding BACT in general establish binding regulatory requirements; such requirements are contained in the regulations and implementation plans referred to above. Rather, this document is intended to guide permitting officials in those areas subject to the federal PSD regulations 40 CFR 52.21. The EPA strongly recommends that this guidance also be followed in areas where a PSD program has received SIP approval under 40 CFR 51.166. In any event, both EPA and the States must continue to adhere to the binding regulatory requirements governing BACT determinations. In this regard, EPA notes that it has consistently interpreted the statutory and regulatory BACT definitions as containing two core requirements which EPA believes must be met by any BACT determination, irrespective of whether it is conducted in a "top-down" manner. First, the BACT analysis must include consideration of the most stringent available technologies, i.e., those which provide the "maximum degree of emissions reduction." Second, any decision to require a lesser degree of emissions reduction must be justified by an objective analysis of "energy, environmental, and economic impacts" contained in the record of the permit decision.

A number of terms and acronyms used in this document have specific meanings within the context of new source review (NSR). Since this document is intended for use by permit engineers and others generally familiar with NSR, these terms are used throughout this document, often without definition. To aid users of the guidance document who are unfamiliar with these terms, general definitions of these terms can be found in Appendix A. The specific regulatory definitions for most of the terms can be found in 40 CFR 52.21. Should there be any inconsistency between the definitions contained in Appendix A and the regulatory definitions or other requirements found in Part 40 of the Code of Federal Regulations, including any policies or interpretations issued pursuant to those regulations following the issuance of this document, the regulations and policies, or interpretations shall govern.

## II. INTRODUCTION

On December 1, 1987, the EPA Assistant Administrator for Air and Radiation issued a memorandum that implemented certain program initiatives designed to improve the effectiveness of the new source review (NSR) programs within the confines of existing regulations and state implementation plans. Among these was the "top-down" method for determining best available control technology (BACT). The purpose of this document is to provide a detailed description of the top-down method in order to assist permitting authorities and prevention of significant deterioration (PSD) applicants in conducting BACT analyses.

In brief, the top-down process provides that all available control technologies be ranked in descending order of control effectiveness. The PSD applicant first examines the most stringent -- or "top" -- alternative. That alternative is established as BACT unless the applicant demonstrates, and the permitting authority in its informed judgment agrees, that technical considerations, or energy, environmental, or economic impacts justify a conclusion that the most stringent technology is not "achievable" in that case. If the most stringent technology is eliminated in this fashion, then the next most stringent alternative is considered, and so on.

There are two key criteria that must be satisfied in any BACT analysis under the Clean Air Act. First, the permit applicant must consider the most stringent control technologies available. Second, if the applicant proposes less stringent controls, it must demonstrate, using objective data, that the most stringent controls are not achievable due to source-specific energy, environmental, or economic impacts, and the permitting authority must exercise its informed judgment before accepting that determination. The EPA's adoption of a top-down approach reflects concern that the implementation of other prior approaches to determining BACT was deficient in fulfilling these key BACT requirements. The EPA expects that the top-down approach will be more effective than other approaches in assuring that BACT analyses comply with the requirements of the Clean Air Act.

# III. BACT APPLICABILITY

The applicability criteria for imposition of the BACT requirement vary from State to State. In general, BACT is required of those new sources and modifications to existing sources which exceed some specified trigger level. The trigger level is bases on potential emissions.

The BACT requirement applies to each individual new or modified affected emissions unit and pollutant emitting activity. Also, individual BACT determinations are performed for each pollutant emitted from the same emission unit. Consequently, the BACT determination must separately address, for each regulated pollutant with a significant emissions increase at the source, air pollution controls for each emissions unit or pollutant emitting activity subject to review.

# IV. A STEP BY STEP SUMMARY OF THE TOP-DOWN PROCESS

Table IV-1 shows the five basic steps of the top-down procedure, including some of the key elements associated with each of the individual steps. A brief description of each step follows.

## IV.A. STEP 1--IDENTIFY ALL CONTROL TECHNOLOGIES.

The first step in a "top-down" analysis is to identify, for the emissions unit in question (the term "emissions unit" should be read to mean emissions unit, process or activity), all "available" control options. Available control options are those air pollution control technologies or techniques with a practical potential for application to the emissions unit and the regulated pollutant under evaluation. Air pollution control technologies and techniques include the application of production process or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of the affected pollutant. This includes technologies employed outside of the United States. In some circumstances inherently lower-polluting processes are appropriate for consideration as available control alternatives. The control alternatives should include not only existing controls for the source category in question, but also (through technology transfer) controls applied to similar source categories and gas streams, and innovative control technologies. Technologies required under lowest achievable emission rate (LAER) determinations are available for BACT purposes and must also be included as control alternatives and usually represent the top alternative.

In the course of the BACT analysis, one or more of the options may be eliminated from consideration because they are demonstrated to be technically infeasible or have unacceptable energy, economic, and environmental impacts on a case-by-case (or site-specific) basis. However, at the outset, applicants

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TABLE IV-1. - KEY STEPS IN THE "TOP-DOWN" BACT PROCESS

STEP 1: *IDENTIFY ALL CONTROL TECHNOLOGIES.*

- LIST is comprehensive (LAER included).

STEP 2: *ELIMINATE TECHNICALLY INFEASIBLE OPTIONS.*

- A demonstration of technical infeasibility should be clearly documented and should show, based on physical, chemical, and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review.

STEP 3: *RANK REMAINING CONTROL TECHNOLOGIES BY CONTROL EFFECTIVENESS.*

Should include:

- control effectiveness (percent pollutant removed);
- expected emission rate (tons per year);
- expected emission reduction (tons per year);
- energy impacts (BTU, kWh);
- environmental impacts (other media and the emissions of toxic and hazardous air emissions); and
- economic impacts (total cost effectiveness, incremental cost effeciveness).

STEP 4: *EVALUATE MOST EFFECTIVE CONTROLS AND DOCUMENT RESULTS.*

- Case-by-case consideration of energy, environmental, and economic impacts.
- If top option is not selected as BACT, evaluate next most effective control option.

STEP 5: *SELECT BACT*

- Most effective option not rejected is BACT.

should initially identify all control options with potential application to the emissions unit under review.

## IV.B. STEP 2--ELIMINATE TECHNICALLY INFEASIBLE OPTIONS.

In the second step, the technical feasibility of the control options identified in step one is evaluated with respect to the source-specific (or emissions unit-specific) factors. In general, a demonstration of technical infeasibility should be clearly documented and should show, based on physical, chemical, and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review. Technically infeasible control options are then eliminated from further consideration in the BACT analysis.

For example, in cases where the level of control in a permit is not expected to be achieved in practice (e.g., a source has received a permit but the project was cancelled, or every operating source at that permitted level has been physically unable to achieve compliance with the limit), and supporting documentation showing why such limits are not technically feasible is provided, the level of control (but not necessarily the technology) may be eliminated from further consideration. However, a permit requiring the application of a certain technology or emission limit to be achieved for such technology usually is sufficient justification to assume the technical feasibility of that technology or emission limit.

## IV.C. STEP 3--RANK REMAINING CONTROL TECHNOLOGIES BY CONTROL EFFECTIVENESS.

In step 3, all remaining control alternatives not eliminated in step 2 are ranked and then listed in order of over all control effectiveness for the pollutant under review, with the most effective control alternative at the top. A list should be prepared for each pollutant and for each emissions unit (or grouping of similar units) subject to a BACT analysis. The list should present the array of control technology alternatives and should include the following types of information:

- control efficiencies (percent pollutant removed);
- expected emission rate (tons per year, pounds per hour);
- expected emissions reduction (tons per year);
- economic impacts (cost effectiveness);
- environmental impacts (includes any significant or unusual other media impacts (e.g., water or solid waste), and, at a minimum, the impact of each control alternative on emissions of toxic or hazardous air contaminants);
- energy impacts.

However, an applicant proposing the top control alternative need not provide cost and other detailed information in regard to other control options. In such cases the applicant should document that the control option chosen is, indeed, the top, and review for collateral environmental impacts.

**IV.D. STEP 4--EVALUATE MOST EFFECTIVE CONTROLS AND DOCUMENT RESULTS.**

After the identification of available and technically feasible control technology options, the energy, environmental, and economic impacts are considered to arrive at the final level of control. At this point the analysis presents the associated impacts of the control option in the listing. For each option the applicant is responsible for presenting an objective evaluation of each impact. Both beneficial and adverse impacts should be discussed and, where possible, quantified. In general, the BACT analysis should focus on the direct impact of the control alternative.

If the applicant accepts the top alternative in the listing as BACT from an economic and energy standpoint, the applicant proceeds to consider whether impacts of unregulated air pollutants or impacts in other media would justify selection of an alternative control option. If there are no outstanding issues regarding collateral environmental impacts, the analysis is ended and the results proposed as BACT. In the event that the top candidate is shown to be inappropriate, due to energy, environmental, or economic impacts, the rationale for this finding should be fully documented for the public record. Then the next most stringent alternative in the listing becomes the new control candidate and is similarly evaluated. This process continues until the technology under consideration cannot be eliminated by any source-specific environmental, energy, or economic impacts which demonstrate that alternative to be inappropriate as BACT.

## IV.E. STEP 5--SELECT BACT

The most effective control option not eliminated in step 4 is proposed as BACT for the pollutant and emission unit under review.

# V. TOP-DOWN ANALYSIS DETAILED PROCEDURE

## V.A. IDENTIFY ALTERNATIVE EMISSION CONTROL TECHNIQUES (STEP 1)

The objective in step 1 is to identify all control options with potential application to the source and pollutant under evaluation. Later, one or more of these options may be eliminated from consideration because they are determined to be technically infeasible or to have unacceptable energy, environmental or economic impacts.

Each new or modified emission unit (or logical grouping of new or modified emission units) subject to PSD is required to undergo BACT review. BACT decisions will generally be made on the information presented in the BACT analysis, including the degree to which effective control alternatives were identified and evaluated. Potentially applicable control alternatives can be categorized in three ways.

- *Inherently Lower-Emitting Processes/Practices*, including the use of materials and production processes and work practices that *prevent* emissions and result in lower "production-specific" emissions; and
- *Add-on Controls*, such as scrubbers, fabric filters, thermal oxidizers and other devices that *control* and *reduce* emissions after they are produced.
- *Combinations of Inherently Lower Emitting Processes and Add-on Controls*. For example, the application of combustion and post-combustion controls to reduce $NO_x$ emissions at a gas-fired turbine.

The top-down BACT analysis should consider potentially applicable control techniques from all three categories. Lower-polluting processes should be considered based on demonstrations made on the basis of manufacturing identical or similar products from identical or similar raw materials or fuels. Add-on controls, on the other hand, should be considered based on the physical and chemical characteristics of the pollutant-bearing emission stream. Thus, candidate add-on controls may have been applied to a broad range of emission unit types that are similar, insofar as emissions characteristics, to the emissions unit undergoing BACT review.

### V.A.1. DEMONSTRATED AND TRANSFERABLE TECHNOLOGIES

Applicants are expected to identify all demonstrated and potentially applicable control alternatives. Information sources to consider include:

- o EPA's BACT/LAER Clearinghouse and Control Technology Center;
- o Best Available Control Technology Guideline - South Coast Air Quality Management District;
- o control technology vendors;
- o Federal/State/Local new source review permits and associated inspection/performance test reports;
- o environmental consultants;
- o technical journals, reports and newsletters (e.g., JAPCA and the McIvaine reports), air pollution control seminars; and
- o EPA's New Source Review (NSR) bulletin board.

The applicant should make a good faith effort to compile appropriate information from available information sources, including any sources specified as necessary by the permit agency. The permit agency should review the background search and resulting list of control alternatives presented by the applicant to check that it is complete and comprehensive.

In identifying control technologies, the applicant needs to survey the range of potentially available options without regard to where and how the technologies have been applied previously. This includes technologies in application outside the United States to the extent that the technologies have been successfully demonstrated in practice on full scale operations. Usually, technologies which have not yet been applied to (or permitted for) full scale operations are not considered available; an applicant should be able to purchase or construct a process or control device that has already been demonstrated in practice.

While EPA's intent is to ensure broad consideration in determining alternative control techniques for consideration as BACT, the focus is on the technologies with a demonstrated potential to achieve the highest levels of control. It is not necessary to consider unreasonably large numbers of options. For example, control options incapable of meeting an applicable New Source Performance Standard (NSPS) or State Implementation Plan (SIP) limit would not meet the definition of BACT under any circumstances and need not be considered in the BACT analysis and are not to be considered in step 1.

The fact that a NSPS for a source category does not require a certain level of control or particular control technology does not preclude its consideration in the top-down BACT analysis. For example, the fact that $SO_2$ scrubbing is not required under the Subpart Db of the NSPS for Industrial-Commercial-Institutional Steam Generating Units does not preclude the inclusion of scrubbing from the list of available technologies or the BACT selection process. In the BACT analysis, an NSPS simply defines the minimal level of control. The fact that a more stringent technology was not selected for the NSPS (or that a pollutant is not regulated by an NSPS) does not exclude that control alternative or technology as a BACT candidate. When developing a list of possible BACT alternatives, the only reason for comparing control options to an NSPS is to determine whether the control option would result in an emissions level less stringent than the NSPS. If so, the option is unacceptable.

### V.A.2. INNOVATIVE TECHNOLOGIES

Although <u>not required</u> in step 1, innovative technologies <u>may</u> also be evaluated and proposed as BACT. To be considered innovative, a control technique must meet the provisions of 40 CFR 52.21(b)(19) or, where appropriate, the applicable SIP definition. In essence, if a developing technology has the potential to achieve a more stringent emissions level than otherwise would constitute BACT or the same level at a lower cost, it may be proposed as an innovative control technology. Innovative technologies are distinguished from technology transfer BACT candidates in that an innovative technology is still under development and has not been demonstrated in a commercial application on identical or similar emission units. In certain instances, the distinction between innovative and transferable technology may not be straightforward. In these cases, it is recommended that the permit agency consult with EPA prior to proceeding with the issuance of an innovative control technology waiver.

Applicants should note that EPA has in the past approved only a limited number of innovative control technology waivers for a specific control technology; if a waiver has been applied for or granted to a similar source for the same technology, granting of additional waivers to similar sources is highly unlikely.

V.A.3. CONSIDERATION OF INHERENTLY LOWER POLLUTING PROCESSES/PRACTICES

Historically, EPA has not considered the BACT requirement as a means to redefine the design of the source when considering available control alternatives. For example, applicants proposing to construct a coal-fired electric generator, have not been required by EPA as part of a BACT analysis to consider building a natural gas-fired electric turbine although the turbine may be inherently less polluting per unit product (in this case electricity). However, this is an aspect of the PSD permitting process in which states have the discretion to engage in a broader analysis if they so desire. Thus, although the gas turbine normally would not be included in the list of control alternatives for a coal-fired boiler. However, there may be instances where, in the permit authority's judgment, the consideration of alternative production processes is warranted and appropriate for consideration in the

BACT analysis. A production process is defined in terms of its physical and chemical unit operations used to produce the desired product from a specified set of raw materials. In such cases, the permit agency should require the applicant to include the inherently lower-polluting process in the list of BACT candidates.

In many cases, a given production process or emissions unit can be made to be inherently less polluting (e.g; the use of water-based versus solvent based paints in a coating operation or a coal-fired boiler designed to have a low emission factor for $NO_x$). In such cases the ability of design considerations to make the process inherently less polluting must be considered as a control alternative for the source. Inherently lower-polluting processes/practice are usually more environmentally effective because of lower amounts of solid wastes and waste water than are generated with add-on controls. These factors are considered in the cost, energy and environmental impacts analyses in step 4 to determine the appropriateness of the additional add-on option.

Combinations of inherently lower-polluting processes/practices (or a process made to be inherently less polluting) and add-on controls are likely to yield more effective means of emissions control than either approach alone. Therefore, the option to utilize a inherently lower-polluting process does not, in and of itself, mean that no additional add-on controls need be included in the BACT analysis. These combinations should be identified in step 1 of the top down process for evaluation in subsequent steps.

### V.A.4. EXAMPLE

The process of identifying control technology alternatives (step 1 in the top-down BACT process) is illustrated in the following hypothetical example.

## Description of Source

A PSD applicant proposes to install automated surface coating process equipment consisting of a dip-tank priming stage followed by a two-step spray application and bake-on enamel finish coat. The product is a specialized electronics component (resistor) with strict resistance property specifications that restrict the types of coatings that may be employed.

## List of Control Options

The source is not covered by an applicable NSPS. A review of the BACT/LAER Clearinghouse and other appropriate references indicates the following control options may be applicable:

Option #1: water-based primer and finish coat;

*[The water-based coatings have never been used in applications similar to this.]*

Option #2: low-VOC solvent/high solids coating for primer and finish coat;

*[The high solids/low VOC solvent coatings have recently been applied with success with similar products (e.g., other types of electrical components).]*

Option #3: electrostatic spray application to enhance coating transfer efficiency; and

*[Electrostatically enhanced coating application has been applied elsewhere on a clearly similar operation.]*

Option #4: emissions capture with add-on control via incineration or carbon adsorber equipment.

*[The VOC capture and control option (incineration or carbon adsorber) has been used in many cases involving the coating of different products and the emission stream characteristics are similar to the proposed resistor coating process and is identified as an option available through technology transfer.]*

Since the low-solvent coating, electrostatically enhanced application, and ventilation with add-on control options may reasonably be considered for use in combination to achieve greater emissions reduction efficiency, a total of eight control options are eligible for further consideration. The options include each of the four options listed above and the following four combinations of techniques:

> Option #5: **low-solvent coating with electrostatic applications without ventilation and add-on controls;**
>
> Option #6: **low-solvent coating without electrostatic applications with ventilation and add-on controls;**
>
> Option #7: **electrostatic application with add-on control**; and
>
> Option #8: **a combination of all three technologies.**

A "no control" option also was identified but eliminated because the applicant's State regulations require at least a 75 percent reduction in VOC emissions for a source of this size. Because "no control" would not meet the State regulations it could not be BACT and, therefore, was not listed for consideration in the BACT analysis.

Summary of Key Points

The example illustrates several key guidelines for identifying control options. These include:

- o All available control techniques must be considered in the BACT analysis.
- o Technology transfer must be considered in identifying control options. The fact that a control option has never been applied to process emission units similar or identical to that proposed does not mean it can be ignored in the BACT analysis if the potential for its application exists.
- o Combinations of techniques should be considered to the extent they result in more effective means of achieving stringent emissions levels represented by the "top" alternative, particularly if the "top" alternative is eliminated.

## V.B. TECHNICAL FEASIBILITY ANALYSIS (STEP 2)

In step 2, the technical feasibility of the control options identified in step 1 is evaluated. This step is straightforward and simple for control technologies that are demonstrated--if the control technology has been installed and operated successfully on the type of source under review, it is demonstrated and it is technically feasible. For control technologies that are not demonstrated in the sense indicated above, the analysis is somewhat more involved.

Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability." A technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

Availability in this context is further explained using the following process commonly used for bringing a control technology concept to reality as a commercial product:

- concept;
- research and patenting;
- bench scale or laboratory testing;
- pilot scale testing;
- licensing and commercial demonstration; and
- commercial sales.

A control technique is considered available, within the context presented above, if it has reached the licensing and commercial sales stage of development. A source would not be required to experience extended time delays or resource penalties to allow research to be conducted on a new technique. Neither is it expected that an applicant would be required to experience extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, technologies in the pilot scale testing stages of development would not be considered available for BACT review. An exception would be if the technology were proposed and permitted under the qualifications of an innovative control device consistent with the provisions of 40 CFR 52.21(v) or, where appropriate, the applicable SIP.

In general, if a control option is commercially available, it falls within the options to be identified in step 1. Commercial availability by itself, however, is not necessarily sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration.

Technical judgment on the part of the applicant and the review authority is to be exercised in determining whether a control alternative is applicable to the source type under consideration. In general, a commercially available control option will be presumed applicable if it has been or is soon to be deployed (e.g., is specified in a permit) on the same or a similar source type. Absent a showing of this type, technical feasibility would be based on examination of the physical and chemical characteristics of the pollutant-bearing gas stream and comparison to the gas stream characteristics of the source types to which the technology had been applied previously. Deployment of the control technology on an existing source with similar gas stream characteristics is generally sufficient basis for concluding technical feasibility barring a demonstration to the contrary.

Alternately, for process-type control alternatives, more general criteria must be considered in determining whether or not it is applicable to the source in question. The decision would have to be based on an assessment of the similarities and differences between the proposed source and other sources to which the process technique had been applied previously. Absent an explanation of unusual circumstances by the applicant showing why a particular process cannot be used on the proposed source the review authority may presume it is technically feasible.

In practice, decisions about technical feasibility are the purview of the review authority. Further, a presumption of technical feasibility may be made by the review authority based solely on technology transfer. Decisions of this type would be made in the case of add-on controls by comparing the physical and chemical characteristics of the exhaust gas stream from the unit under review to those of the unit from which the technology is to be transferred. Unless significant differences between source types exist that are pertinent to the successful operation of the control device, the control option is presumed to be technically feasible.

Within the context of the top-down procedure, an applicant becomes involved with the issue of technical feasibility in asserting that a control option identified in Step 1 is technically infeasible. In this instance, the applicant should make a practical, factual demonstration of infeasibility based on commercial unavailability and/or unusual circumstances which exist with application of the control to the applicant's emission units. Generally, such a demonstration would involve an evaluation of the pollutant-bearing gas stream characteristics and the capabilities of the technology. Also a showing of unresolvable technical difficulty with applying the control would constitute a showing of technical infeasibility (e.g., size of the unit, location of the proposed site, and operating problems related to specific circumstances of the source). Where the resolution of technical difficulties is a matter of cost, the applicant should consider the technology as technically feasible. The economic feasibility of a control alternative is reviewed in the economic impacts portion of the BACT selection process.

A demonstration of technical infeasibility is based on a technical assessment considering physical, chemical and engineering principles and/or empirical data showing that the technology would not work on the emissions unit under review, or that unresolvable technical difficulties would preclude the successful deployment of the technique. Physical modifications needed to resolve technical obstacles do not in and of themselves provide a justification for eliminating the control technique on the basis of technical infeasibility. However, the cost of such modifications can be considered in estimating cost and economic impacts which, in turn, may form the basis for eliminating a control technology.

Vendor guarantees may provide an indication of commercial availability and the technical feasibility of a control technique and could contribute to a determination of technical feasibility or technical infeasibility, depending on circumstances. However, EPA does not consider a vendor guarantee alone to be sufficient justification that a control option will work. Conversely, lack of a vendor guarantee by itself does not present sufficient justification that a control option or an emissions limit is technically infeasible. Generally, decisions about technical feasibility will be based on chemical, and engineering analyses (as discussed above) in conjunction with information about vendor guarantees.

A possible outcome of the top-down BACT procedures discussed in this document is the evaluation of multiple control technology alternatives which result in essentially equivalent emissions. It is not EPA's intent to encourage evaluation of unnecessarily large numbers of control alternatives for every emissions unit. Consequently, judgment should be used in deciding what alternatives will be evaluated in detail in the impacts analysis (Step 4) of the top-down procedure discussed in a later section. For example, if two or more control techniques result in control levels that are essentially identical considering the uncertainties of emissions factors and other parameters pertinent to estimating performance, the source may wish to point this out and make a case for evaluation and use only of the less costly of these options. The scope of the BACT analysis should be narrowed in this way only if there is a negligible difference in emissions and collateral environmental impacts between control alternatives. Such cases should be discussed with the reviewing agency before a control alternative is dismissed at this point in the BACT analysis due to such considerations.

It is encouraged that judgments of this type be discussed during a preapplication meeting between the applicant and the review authority. In this way, the applicant can be better assured that the analysis to be conducted will meet BACT requirements. The appropriate time to hold such a meeting during the analysis is following the completion of the control hierarchy discussed in the next section.

Summary of Key Points

In summary, important points to remember in assessing technical feasibility of control alternatives include:

- A control technology that is "demonstrated" for a given type or class of sources is technically feasible unless source-specific factors exist and are documented to justify technical infeasibility.
- Technical feasibility of technology transfer control candidates generally is assessed based on an evaluation of pollutant-bearing gas stream characteristics for the proposed source and other source types to which the control had been applied previously.
- Innovative controls that have not been demonstrated on any source type similar to the proposed source need not be considered in the BACT analysis.
- The applicant is responsible for providing a basis for assessing technical feasibility or infeasibility and the review authority is

responsible for the decision on what is and is not technically feasible.

## V.C. RANKING THE TECHNICALLY FEASIBLE ALTERNATIVES TO ESTABLISH A CONTROL HIERARCHY (STEP 3)

Step 3 involves ranking all the technically feasible control alternatives which have been previously identified in Step 2. For the regulated pollutant and emissions unit under review, the control alternatives are ranked-ordered from the most to the least effective in terms of emission reduction potential. The primary focus in the ranking at this time is the overall capabilities of the control technology options. Later, once the control technology is determined, the focus shifts to the specific limits to be met by the source.

Two key issues that must often be addressed in this process include:

- What common units should be used to compare emissions performance levels among options?
- How should control techniques that can operate over a wide range of emission performance levels (e.g., scrubbers, etc.) be considered in the analysis?

### V.C.1. CHOICE OF UNITS OF EMISSIONS PERFORMANCE TO COMPARE LEVELS AMONGST CONTROL OPTIONS

In general, this issue arises when comparing inherently lower-polluting processes to one another or to add-on controls. For example, direct comparison of powdered (and low-VOC) coatings and vapor recovery and control systems at a metal furniture finishing operation is difficult because of the different units of measure for their effectiveness. In such cases, it is probably most effective to express emissions performance as an average steady state emissions level per unit of product or process. Other examples are:

- pounds VOC emission per gallons of solids applied,
- pounds PM emission per ton of cement produced,

- pounds $SO_2$ emissions per million Btu heat input, and
- pounds $SO_2$ emission per kilowatt of electric power produced,

Calculating annual emissions levels (tons/yr) using these units becomes straightforward once the projected annual production or processing rates are known. The result is an estimate of the annual pollutant emissions that the source or emissions unit will emit. Annual "potential" emission projections are calculated using the source's maximum design capacity and full year round operation (8760 hours), unless the final permit is to include federally enforceable conditions restricting the source's capacity or hours of operation. However, emissions estimates used for the purpose of calculating and comparing the cost effectiveness of a control option are based on a different approach (see section V.D.2.b. COST EFFECTIVENESS).

## V.C.2. CONTROL TECHNIQUES WITH A WIDE RANGE OF EMISSIONS PERFORMANCE LEVELS

The objective of the top-down BACT analysis is to not only identify the best control technology, but also a corresponding performance level (or in some cases performance range) for that technology considering source-specific factors. Many control techniques, including both add-on controls and inherently lower polluting processes can perform at a wide range of levels. Scrubbers, high and low efficiency electrostatic precipitators (ESPs), low-VOC coatings are examples of just a few. It is not the EPA's intention to require analysis of each possible level of efficiency for a control technique, as such an analysis would result in a large number of options. Rather, the applicant should use the most recent regulatory decisions and performance data for identifying the emissions performance level(s) to be evaluated in all cases.

The EPA does not expect an applicant to necessarily accept an emission limit as BACT solely because it was required previously of a similar source type. While the most effective level of control must be considered in the BACT analysis, different levels of control for a given control alternative can be considered. This may occur, for example, the consideration of a lower level of control for a given technology may be warranted in cases where past decisions involved different source types. The evaluation of an alternative control level can also be considered where the applicant can to the satisfaction of the permit agency demonstrate that other considerations demonstrate the need to also evaluate the control alternative at a lower level of effectiveness.

Manufacturer's data, engineering estimates and the experience of other sources provide the basis for determining achievable limits. Consequently, in the evaluation, latitude exists to consider any special circumstances pertinent to the specific source under review, or regarding the prior application of the control alternative, in assessing the capability of the control alternative. However, the basis for choosing the alternate level (or range) of control in the BACT analysis must be well documented in the application. In the absence of a showing of differences between the proposed source and previously permitted sources achieving lower emissions limits, the permit agency should conclude that the lower emissions limit is representative for that control alternative.

The permit agency should require an applicant to consider a control technology alternative otherwise eliminated by the applicant, if the operation of that control technology at a lower level of control (but still higher than the next control technology alternative) could no longer warrant the elimination of the alternative. For example, while a scrubber operating at 98% efficiency may be eliminated as BACT by the applicant due to source specific economic considerations, the scrubber operating in the 90% to 95% efficiency range may not have an adverse economic impact.

In summary, when reviewing a control technology with a wide range of emission performance levels, it is presumed that the source can achieve the same emission reduction level as another source unless the applicant demonstrates that there are source-specific factors or other relevant information that provide a technical, economic, energy or environmental justification to do otherwise. Also, a control technology that has been eliminated as having an adverse economic impact at its highest level of performance, may be acceptable at a lesser level of performance. For example, this can occur when the cost effectiveness of a control technology at its highest level of performance greatly exceeds the cost of that control technology at a somewhat lower level (or range) of performance.

### V.C.3. ESTABLISHMENT OF THE CONTROL OPTIONS HIERARCHY

After determining the emissions performance levels (in common units) of each control technology option identified in Step 2, a hierarchy is established that places at the "top" the control technology option that achieves the lowest emissions level. Each other control option is then placed after the "top" in the hierarchy by its respective emissions performance level, ranked from lowest emissions to highest emissions (most effective to least stringent effective emissions control alternative).

From the hierarchy of control alternatives the applicant should develop a chart (or charts) displaying the control hierarchy and, where applicable,:

- o expected emission rate (tons per year, pounds per hour);
- o emissions performance level (e.g., percent pollutant removed, emissions per unit product, lb/MMbtu, ppm);
- o expected emissions reduction (tons per year);
- o economic impacts (total costs, cost effectiveness, incremental cost effectiveness);
- o environmental impacts (includes any significant or unusual other media impacts (e.g., water or solid waste), and the relative ability of each control alternative to control emissions of toxic or hazardous air contaminants);
- o energy impacts (indicate any significant energy benefits or disadvantages).

This should be done for each pollutant and for each emissions unit (or grouping of similar units) subject to a BACT analysis. The chart is used in comparing the control alternatives during step 4 of the BACT selection process. Some sample charts are displayed in Table V-1 and Table V-2. Completed sample charts accompany the example BACT analyses provided in section VII.

At this point, it is recommended that the applicant contact the reviewing agency to determine whether the agency feels that any other applicable control alternative should be evaluated or if any issues require special attention in the BACT selection process.

## V.D. THE BACT SELECTION PROCESS (STEP 4)

After identification of available control options is the consideration of energy, environmental, and economic impacts and the selection of the final level of control. The applicant is responsible for presenting an objective evaluation of each impact. Consequently, both beneficial and adverse impacts should be discussed and, where possible, quantified. In general, the BACT analysis should focus on the direct impact of the control alternative.

TABLE V-1. SAMPLE BACT CONTROL HIERARCHY

| Pollutant | Technology | Range of control (%) | Control level for BACT analysis (%) | Emissions limit |
|---|---|---|---|---|
| $SO_2$ | First Alternative | 80-95 | 95 | 15 ppm |
| | Second Alternative | 80-95 | 90 | 30 ppm |
| | Third Alternative | 70-85 | 85 | 45 ppm |
| | Fourth Alternative | 40-80 | 75 | 75 ppm |
| | Fifth Alternative | 50-85 | 70 | 90 ppm |
| | Baseline Alternative | - | - | - |

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TABLE V-2. SAMPLE SUMMARY OF TOP-DOWN BACT IMPACT ANALYSIS RESULTS

| | | | | Economic Impacts | | | Environmental Impacts | | Energy Impacts |
|---|---|---|---|---|---|---|---|---|---|
| Pollutant/ Emissions Unit | Control alternative | Emissions (lb/hr, tpy) | Emissions reduction(a) (tpy) | Total annualized cost(b) ($/yr) | Total Cost effectiveness(c) ($/ton) | Incremental cost effectiveness(d) ($/ton) | Toxics impact(e) (Yes/No) | Adverse environmental impacts(f) (Yes/No) | Incremental increase over baseline(g) (MMBtu/yr) |
| NOx/Unit A | Top Alternative | | | | | | | | |
| | Other Alternative(s) | | | | | | | | |
| | Baseline Alternative | | | | | | | | |
| NOx/Unit B | Top Alternative | | | | | | | | |
| | Other Alternative(s) | | | | | | | | |
| | Baseline Alternative | | | | | | | | |
| SO2/Unit A | Top Alternative | | | | | | | | |
| | Other Alternative(s) | | | | | | | | |
| | Baseline Alternative | | | | | | | | |
| SO2/Unit B | Top Alternative | | | | | | | | |
| | Other Alternative(s) | | | | | | | | |
| | Baseline Alternative | | | | | | | | |

(a) Emissions reduction over baseline level.
(b) Total annualized cost (capital, direct, and indirect) of purchasing, installing, and operating the proposed control alternative. A capital recovery factor approach using a real interest rate (i.e., absent inflation) is used to express capital costs in present-day annual costs.
(c) Cost Effectiveness is total annualized cost for the control option divided by the emissions reductions resulting from the option.
(d) The incremental cost effectiveness is the difference in annualized cost for the control option and the next most effective control option divided by the difference in emissions reduction resulting from the respective alternatives.
(e) Toxics impact means there is a toxics impact consideration for the control alternative.
(f) Adverse environmental impact means there is an adverse environmental impact consideration with the control alternative.
(g) Energy impacts are the difference in total project energy requirements with the control alternative and the baseline control alternative expressed in equivalent millions of Btus per year.

Step 4 validates the suitability of the top control option in the listing for selection as BACT, or provides clear justification why the top candidate is inappropriate as BACT. If the applicant accepts the top alternative in the listing as BACT from an economic and energy standpoint, the applicant proceeds to consider whether collateral environmental impacts (e.g., emissions of unregulated air pollutants or impacts in other media) would justify selection of an alternative control option. If there are no outstanding issues regarding collateral environmental impacts, the analysis is ended and the results proposed as BACT. In the event that the top candidate is shown to be inappropriate, due to energy, environmental, or economic impacts, the rationale for this finding needs to be fully documented for the public record. Then, the next most effective alternative in the listing becomes the new control candidate and is similarly evaluated. This process continues until the control technology under consideration cannot be eliminated by any source-specific environmental, energy, or economic impacts which demonstrate that the alternative is inappropriate as BACT.

Determining a control alternative to be inappropriate involves a demonstration that circumstances exist at the source under review which distinguish it from other sources where the control alternative may have been required previously, or that argue against the transfer of technology or application of new technology. Alternately, where a control technique has been applied to only one or a very limited number of sources, the applicant can identify those characteristic(s) unique to those sources that may have made the application of the control appropriate in those case(s) but not for the source under consideration. In showing unusual circumstances, objective factors dealing with the control technology and its application should be the focus of the consideration. The specifics of the situation will determine to what extent an appropriate demonstration has been made regarding the elimination of the more effective alternative(s) as BACT. In the absence of unusual circumstance, the presumption is that sources within the same category are similar in nature, and that cost and other impacts that have been borne by one source of a given source category may be borne by another source of the same source category.

## V.D.1. ENERGY IMPACTS ANALYSIS

Applicants should examine the energy requirements of the control technology and determine whether the use of that technology results in any significant or unusual energy penalties or benefits. A source may, for example, benefit from the combustion of a concentrated gas stream rich in volatile organic compounds; on the other hand, more often extra fuel or electricity is required to power a control device or incinerate a dilute gas stream. If such benefits or penalties exist, they should be quantified. Because energy penalties or benefits can usually be quantified in terms of additional cost or income to the source, the energy impacts analysis can, in most cases, simply be factored into the economic impacts analysis. However, certain types of control technologies have inherent energy penalties associated with their use. While these penalties should be quantified, so long as they are within the normal range for the technology in question, such penalties should not, in general, be considered adequate justification for nonuse of that technology.

Energy impacts should consider only <u>direct</u> energy consumption and not <u>indirect</u> energy impacts. For example, the applicant could estimate the direct energy impacts of the control alternative in units of energy consumption at the source ( e.g., Btu, kWh, barrels of oil, tons of coal). The energy requirements of the control options should be shown in terms of total (and in certain cases also incremental) energy costs per ton of pollutant removed. These units can then be converted into dollar costs and, where appropriate, factored into the economic analysis.

As noted earlier, indirect energy impacts (such as energy to produce raw materials for construction of control equipment) generally are not considered. However, if the permit authority determines, either independently or based on a showing by the applicant, that the indirect energy impact is unusual or significant and that the impact can be well quantified, the indirect impact may be considered. The energy impact should still focus on the application of the control alternative and not a concern over general energy impacts associated with the project under review as compared to alternative projects for which a permit is not being sought, or as compared to a pollution source which the project under review would replace (e.g., it would be inappropriate to argue that a cogeneration project is more efficient in the production of electricity than the powerplant production capacity it would displace and, therefore, should not be required to spend equivalent costs for the control of the same pollutant).

The energy impact analysis may also address concerns over the use of locally scarce fuels. The designation of a scarce fuel may vary from region to region, but in general a scarce fuel is one which is in short supply locally and can be better used for alternative purposes, or one which may not be reasonably available to the source either at the present time or in the near future.

### V.D.2. COST/ECONOMIC IMPACTS ANALYSIS

Cost effectiveness, in terms of dollars per ton of pollutant emissions reduction, is one of the key criteria to be used in assessing the economic feasibility of a control alternative. Incremental cost effectiveness may also be considered in conjunction with total cost effectiveness. In the economic impacts analysis, primary consideration should be given to quantifying the cost of control and not the economic situation of the individual source. Consequently, applicants generally should not propose elimination of control alternatives on the basis of economic parameters that provide an indication of the affordability of a control alternative relative to the source. BACT is required by law. Its costs are integral to the overall cost of doing business and are not to be considered an afterthought. Consequently, for control alternatives that have been effectively employed in the same source category, the economic impact of such alternatives on the particular source under review should be not nearly as pertinent to the BACT decision making process as the total and, where appropriate, incremental cost effectiveness of the control alternative. Thus, where a control technology has been successfully applied to similar sources in a source category, an applicant should concentrate on documenting significant cost differences, if <u>any</u>, between the application of the control technology on those other sources and the particular source under review.

Cost effectiveness values above the levels experienced by other sources of the same type and pollutant, are taken as an indication that unusual and persuasive differences exist with respect to the source under review. In addition, where the cost of a control alternative for the specific source reviewed is within the range of normal costs for that control alternative, the alternative, in certain limited circumstances, may still be eligible for elimination. To justify elimination of an alternative on these grounds, the applicant should demonstrate to the satisfaction of the permitting agency that costs of pollutant removal for the control alternative are disproportionately high when compared to the cost of control for that particular pollutant and source in recent BACT determinations. If the circumstances of the differences are adequately documented and explained in the application and are acceptable to the reviewing agency they may provide a basis for eliminating the control alternative.

In all cases, economic impacts need to be considered in conjunction with energy and environmental impacts (e.g., toxics and hazardous pollutant considerations) in selecting BACT. It is possible that the environmental impacts analysis or other considerations (as described elsewhere) would override the economic elimination criteria as described in this section. However, absent overriding environmental impacts concerns or other considerations, an acceptable demonstration of a adverse economic impact can be adequate basis for eliminating the control alternative.

**V.D.2.a. ESTIMATING CONTROL COST**

Once the control technology alternatives and achievable emissions performance levels have been identified, capital and annual costs are developed. This is an important step because these costs will form the basis of the cost and economic impacts used to determine and document if a control alternative should be eliminated on grounds of its economic impacts.

Consistency in the approach to decision-making is a primary objective of the top-down BACT approach. In order to maintain and improve the consistency of BACT decisions made on the basis of cost and economic considerations, procedures for estimating control equipment costs are based on EPA's OAQPS Control Cost Manual and are set forth in Appendix B of this document. Applicants should closely follow the procedures in the appendix and any deviations should be clearly presented and justified in the documentation of the BACT analysis.

Normally the submittal of very detailed and comprehensive project cost data is not necessary. However, where initial control cost projections on the part of the applicant appear excessive or unreasonable (in light of recent cost data) more detailed and comprehensive cost data may be necessary to document the applicant's projections. An applicant proposing the top alternative usually does not need to provide cost data on the other possible control alternatives.

Control technology total cost estimates developed for BACT analyses should be on the order of plus or minus 30 percent accuracy. If more accurate cost data are available (such as specific bid estimates), these should be used. However, these types of costs may not be available at the time permit applications are being prepared. Costs should also be site specific. Some site specific factors are costs of raw materials (fuel, water, chemicals) and labor. For example, in some remote areas costs can be unusually high. For example, remote locations in Alaska may experience a 40 - 50 percent premium on installation costs. The applicant should document any unusual costing assumptions used in the analysis.

Before costs can be estimated, the control system design parameters must be specified. The most important item here is to ensure that the design parameters used in costing are consistent with emissions estimates used in other portions of the PSD application (e.g., dispersion modeling inputs and permit emission limits). In general, the BACT analysis should present vendor-supplied design parameters. Potential sources of other data on design parameters are BID documents used to support NSPS development, control technique guidelines documents, and cost manuals developed by EPA, or control data in trade publications. Table V-3 presents some example design parameters which are important in determining system costs.

To begin, the limits of the area or process segment to be costed is specified. This well defined area or process segment is referred to as the control system battery limits. The second step is to list and cost each major piece of equipment within the battery limits. The top-down BACT analysis should provide this list of costed equipment. The basis for equipment cost estimates also should be documented, either with data supplied by an equipment vendor (i.e., budget estimates or bids) or by a referenced source (such as the OAQPS Control Cost Manual (Fourth Edition), EPA 450/3-90-006, January 1990). Inadequate documentation of battery limits is one of the most common reasons for confusion in comparison of costs of the same controls applied to similar sources. For control options that are defined as inherently lower-polluting processes (and not add-on controls), the battery limits may be the entire process or project.

TABLE V-3. EXAMPLE CONTROL SYSTEM DESIGN PARAMETERS

| Control | Design parameter |
|---|---|
| Wet Scrubbers | Scrubber liquor (water, chemicals, etc.)<br>Gas pressure drop<br>Liquid/gas ratio |
| Carbon Absorbers | Specific chemical species<br>Gas pressure drop<br>lbs carbon/lbs pollutant |
| Condensers | Condenser type<br>Outlet temperature |
| Incineration | Residence time<br>Temperature |
| Electrostatic Precipitator | Specific collection area (ft2/acfm)<br>Voltage density |
| Fabric Filter | Air to cloth ratio<br>Pressure drop |
| Selective Catalytic Reduction | Space velocity<br>Ammonia to NOx molar ratio<br>Pressure drop<br>Catalyst life |

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Design parameters should correspond to the specified emission level. The equipment vendors will usually supply the design parameters to the applicant, who in turn should provide them to the reviewing agency. In order to determine if the design is reasonable, the design parameters can be compared with those shown in documents such as the OAQPS Control Cost Manual, Control Technology for Hazardous Air Pollutants (HAPS) Manual (EPA 625/6-86-014, September 1986), and background information documents for NSPS and NESHAP regulations. If the design specified does not appear reasonable, then the applicant should be requested to supply performance test data for the control technology in question applied to the same source, or a similar source.

V.D.2.b. COST EFFECTIVENESS

Cost effectiveness, or dollars per ton of pollutant reduction, is one of the key economic criterion used to determine if a control option presents adverse economic impacts. By expressing costs in terms of the amount of emission reduction achieved, comparisons can more readily be performed among different locations and types of sources.

Cost effectiveness is calculated as the annualized cost of the control option being considered divided by the baseline emissions minus the control option emissions rate, as shown by the following formula:

$$\text{Cost Effectiveness (dollars per ton removed)} = \frac{\text{Control option annualized cost}}{\text{Baseline emissions rate - Control option emissions rate}}$$

Costs are calculated in (annualized) dollars per year (\$/yr) and emissions rates are calculated in tons per year (tons/yr). The result is a cost effectiveness number in (annualized) dollars per ton (\$/ton) of pollutant removed.

The baseline emissions rate represents a realistic scenario of upper boundary uncontrolled emissions for the source. The NSPS/NESHAP requirements or the application of controls, including other controls necessary to comply with State or local air pollution regulations, are not considered in calculating the baseline emissions. In other words, baseline emissions are essentially uncontrolled emissions, calculated using realistic upper boundary operating assumptions.

A realistic upper-bound case scenario does not mean that the source operates in an absolute worst case manner all the time. For example, in developing a realistic upper boundary case, baseline emissions calculations can also consider inherent physical or operational constraints on the source. Such constraints should accurately reflect the true upper boundary of the source's ability to physically operate and the applicant should submit documentation to verify these constraints. If the applicant does not adequately verify these constraints, then the reviewing agency should consider the application incomplete in cases where the constraints would substantively affect the outcome of the BACT determination. In addition, the reviewing agency may require the applicant to calculate the cost effectiveness based on values exceeding the upper boundary assumptions to determine whether or not the assumptions have a deciding role in the BACT determination. If the assumptions have a deciding role in the BACT determination, the reviewing agency should include enforceable conditions in the permit. For example, VOC emissions from a storage tank might vary significantly with temperature, volatility of liquid stored, and throughput. In this case, it would not be realistic to calculate annual VOC emissions by extrapolating over the course of a year VOC emissions based solely on the hottest summer day. Instead, the range of expected temperatures should be acknowledged in determining baseline emissions. Likewise, it would be unreasonable to assume that gasoline would be stored in a storage tank being build to feed an oil-fired power boiler or that such a tank will be continually filled and emptied. However, on the other hand, an upper boundary case for a storage tank being constructed to store and transfer liquid fuels at a marine terminal would consider emissions based on the most volatile liquids at a high annual through put level since it would not be unrealistic for the tank to operate in such a manner.

In addition, historic upper boundary operating data, typical for the source or industry, may be used in defining baseline emissions in evaluating the cost effectiveness of a control option for a specific source. For example, if for a source or industry, historical upper boundary operations call for two shifts a day, it is not necessary to assume full time (8760 hours) operation on an annual basis in calculating baseline emissions. For comparing cost effectiveness, the same realistic upper boundary assumptions must, however, be used for both the source in question and other sources (or source categories) that will later be compared during the BACT analysis. For example, suppose (based on verified historic data regarding the industry in question) a given source can be expected to utilize numerous colored inks over the course of a year. Each color ink has a different VOC content ranging from a high VOC content to a relatively low VOC content. The source verifies that its operation will indeed call for the application of numerous color inks. In this case, it is more realistic for the baseline emission calculation for the source (and other similar sources) to be based on the expected mix of inks that would be expected to result in an upper boundary case annual VOC emissions rather than an assumption that only one color (i.e, the ink with the highest VOC content) will be applied exclusively during the whole year.

In another example, suppose sources in a particular industry historically operate at most at 85 percent capacity. For BACT cost effectiveness purposes (but <u>not</u> for applicability), an applicant may calculate cost effectiveness using 85 percent capacity. However, in comparing costs with similar sources, the applicant must consistently use an 85 percent capacity factor for the cost effectiveness of controls on those other sources.

Although permit conditions are normally used to make operating assumptions enforceable, the use of "standard industry practice" parameters for cost effectiveness calculations (but <u>not</u> applicability determinations) is acceptable without permit conditions. However, when a source projects operating parameters (e.g., limited hours of operation or capacity utilization, type of fuel, raw materials or product mix or type) that are lower than standard industry practice or which have a deciding role in the BACT determination, then these parameters or assumptions must be made enforceable with permit conditions. If the applicant will not accept enforceable permit conditions, then the reviewing agency should use the absolute worst case uncontrolled emissions. This is necessary to ensure that the source operates within the upper boundary of those parameters used in defining baseline emissions. For example, the baseline emissions calculation for an emergency standby generator may consider the fact that the source does not intend to operate more than 2 weeks a year. On the other hand, baseline emissions associated with a base-loaded turbine would not consider limited hours of operation. This produces a significantly higher level of baseline emissions than in the case of the emergency/standby unit and results in more cost effective controls. As a consequence of the dissimilar baseline emissions, BACT for the two cases could be very different. Therefore, it is important that the applicant confirm that the operational assumptions used to define the source's baseline emissions (and BACT) are genuine. As previously mentioned, this is usually done through enforceable permit conditions which reflect limits on the source's operation which were used to calculate baseline emissions. In certain cases, as discussed above, such explicit permit conditions may not be necessary. For example, a source for which continuous operation would be a physical impossibility (by virtue of its design) may consider this limitation in estimating baseline emissions, without a direct permit limit on operations. However, the permit agency has the responsibility to verify that the source is constructed and operated consistent with the information and design specifications contained in the permit application.

For some sources it may be more difficult to define what emissions level actually represents uncontrolled emissions in calculating baseline emissions. For example, uncontrolled emissions could theoretically be defined for a spray coating operation as the maximum VOC content coating at the highest possible rate of application that the spray equipment could physically process, even though use of such a coating or application rate is unrealistic for the source. Assuming use of a coating with a VOC content and application rate greater than expected is unrealistic and would overestimate the emissions reductions achievable by various control options. The cost effectiveness of the options could also be greatly underestimated. In this case, uncontrolled emission factors should be represented by the highest realistic VOC content of the types of coatings and highest realistic application rates that would be used by the source, rather than by highest VOC based coating materials or rate of application in general.

Conversely, if uncontrolled emissions are underestimated, emissions reductions to be achieved by the various control options would also be underestimated and their cost effectiveness overestimated. For example, this type of situation occurs in the previous example if the baseline for the above coating operation was based on a VOC content coating or application rate that is too low [when the source had the ability and intent to utilize (even infrequently) a higher VOC content coating or application rate].

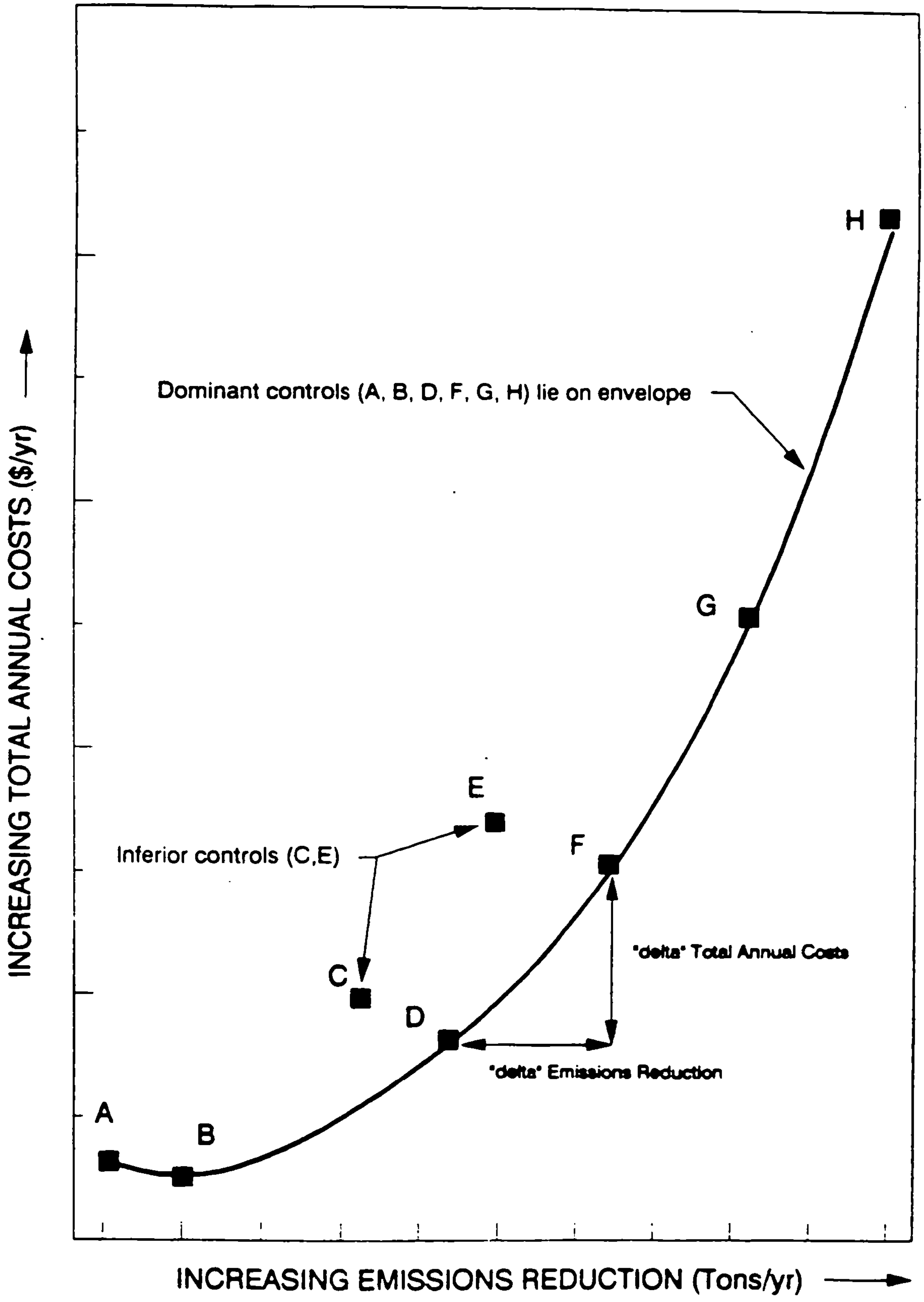
In addition to the cost effectiveness of a control option, incremental cost effectiveness between control options may also be calculated where the control option is not selected. The incremental cost effectiveness should be examined in combination with the total cost effectiveness in order to justify elimination of a control option. For the reasons discussed below, the incremental cost , by itself, generally is not an appropriate basis on which to eliminate a control option. The incremental cost effectiveness calculation compares the costs and emissions performance level of a control option to those of the next most stringent option, as shown in the following formula:

$$\text{Incremental Cost (dollars per incremental ton removed)} = \frac{\text{Control option annualized cost - Annualized cost of next control option}}{\text{Next control option emission rate - Control option emissions rate}}$$

Caution should be exercised in deriving incremental costs of candidate control options. For example, assume that eight technically available control options for analysis are listed in the BACT hierarchy. These are represented as A through H in Figure V-1. In calculating incremental costs, the analysis should only be conducted for control options that are dominant among all possible options. In Figure V-1, the dominant set of control options, A, B, D, F, G, and H, represent the least-cost envelope depicted by the curvilinear line connecting them. Points C and E are inferior options and should not be considered in the derivation of incremental cost effectiveness. Points C and E represent inferior controls because D will buy more emissions reduction for less money than C; and similarly, F will by more reductions for less money than E.

Consequently, care should be taken in selecting the dominant set of controls when calculating incremental costs. First, the control options need to be rank ordered in ascending order of higher costs. Then, as Figure V-1 illustrates, the most reasonable smooth curve of the control options is plotted in such a way that incremental cost effectiveness should be ever-increasing for increasing levels of stringency. The incremental cost effectiveness is then determined by the difference in total annual costs between two contiguous options divided by the difference in emissions reduction. An example is illustrated in Figure V-1 for the incremental cost effectiveness for control option F. The vertical distance, "delta" Total Annual Costs, divided by the horizontal distance, "delta" Emissions Reduction, would be the measure of the incremental cost effectiveness for option F.

# Figure V-1. LEAST-COST ENVELOPE



A comparison of incremental costs can also be useful in evaluating the economic viability of a specific control option over a range of efficiencies. For example, depending on the capital and operational cost of a control device, total and incremental cost may vary significantly (either increasing or decreasing) over the operation range of a control device.

In addition, when evaluating the total or incremental cost effectiveness of a control alternative, reasonable and supportable assumptions regarding control efficiencies should be made. An unrealistically low assessment of the emission reduction potential of a certain technology could result in inflated cost effectiveness figures.

The final decision regarding the reasonableness of calculated cost effectiveness values will be made by the review authority considering previous regulatory decisions. Study cost estimates used in BACT are typically accurate to ± 20 to 30 percent. Therefore, control cost options which are within ± 20 to 30 percent of each other should generally be considered to be indistinguishable when comparing options.

### V.D.2.c. DETERMINING AN ADVERSE ECONOMIC IMPACT

It is important to keep in mind that BACT is primarily a technology-based standard. In essence, if the cost of reducing emissions with the top control alternative, expressed in dollars per ton, is on the same order as the cost previously borne by other sources of the same type in applying that control alternative, the alternative should initially be considered economically achievable, and therefore acceptable as BACT. However, unusual circumstances may greatly affect the cost of controls in a specific application. If so they should be documented. An example of an unusual circumstance might be the unavailability in an arid region of the large amounts of water needed for a scrubbing system. Acquiring water from a distant location might add unreasonable costs to the alternative, thereby justifying its elimination on economic grounds. Consequently, where unusual factors exist that result in cost/economic impacts beyond the range normally incurred by other sources in that category, the technology can be eliminated provided the applicant has adequately identified the circumstances, including the cost or other analyses, that show what is significantly different about the proposed source.

Where the cost of a control alternative for the specific source being reviewed is within the range of normal costs for that control alternative, the alternative may also be eligible for elimination in limited circumstances. This may occur, for example, where a control alternative has not been required as BACT (or its application as BACT has been extremely limited) and there is a clear demarcation between recent BACT control costs in that source category and the control costs for sources in that source category which have been driven by other constraining factors (e.g., need to meet a PSD increment or a NAAQS). To justify elimination of an alternative on these grounds, the applicant should demonstrate to the satisfaction of the permitting agency that costs of pollutant removal (e.g., dollars per total ton removed) for the control alternative are disproportionately high when compared to the cost of control for the pollutant in recent BACT determinations. Specifically, the applicant should document that the cost to the applicant of the control alternative is significantly beyond the range of recent costs normally associated with BACT for the type of facility (or BACT control costs in general) for the pollutant. This type of analysis should demonstrate that a technically and economically feasible control option is nevertheless, by virtue of the magnitude of its associated costs and limited application, unreasonable or otherwise not "achievable" as BACT in the particular case. Total and incremental cost effectiveness numbers are factored into this type of analysis. However, such economic information should be coupled with a comprehensive demonstration, based on objective factors, that the technology is inappropriate in the specific circumstance.

The economic impact portion of the BACT analysis should not focus on inappropriate factors or exclude pertinent factors, as the results may be misleading. For example, the capital cost of a control option may appear excessive when presented by itself or as a percentage of the total project cost. However, this type of information can be misleading. If a large emissions reduction is projected, low or reasonable cost effectiveness numbers may validate the option as an appropriate BACT alternative irrespective of the apparent high capital costs. In another example, undue focus on incremental cost effectiveness can give an impression that the cost of a control alternative is unreasonably high, when, in fact, the total cost effectiveness is well within the normal range of acceptable BACT costs.

### V.D.3. ENVIRONMENTAL IMPACTS ANALYSIS

The environmental impacts analysis is not to be confused with the air quality impact analysis, which is an independent statutory and regulatory requirement and is conducted separately from the BACT analysis. The purpose of the air quality analysis is to demonstrate that the source (using the level of control ultimately determined to be BACT) will not cause or contribute to a violation of any applicable national ambient air quality standard or PSD increment. Thus, regardless of the level of control proposed as BACT, a permit cannot be issued to a source that would cause or contribute to such a violation. In contrast, the environmental impacts portion of the BACT analysis concentrates on impacts other than impacts on air quality (i.e., ambient concentrations) due to emissions of the regulated pollutant in question, such as solid or hazardous waste generation, discharges of polluted water from a control device, visibility impacts, or emissions of unregulated pollutants.

Thus, the fact that a given control alternative would result in only a slight decrease in ambient concentrations of the pollutant in question when compared to a less stringent control alternative should not be viewed as an adverse <u>environmental</u> impact justifying rejection of the more stringent control alternative. However, if the cost effectiveness of the more stringent alternative is exceptionally high, it may (as provided in section V.D.2.) be considered in determining the existence of an adverse economic impact that would justify rejection of the more stringent alternative.

The applicant should identify any significant or unusual environmental impacts associated with a control alternative that have the potential to affect the selection or elimination of a control alternative. Some control technologies may have potentially significant secondary (i.e., collateral) environmental impacts. Scrubber effluent, for example, may affect water quality and land use. Similarly, emissions of water vapor from technologies using cooling towers may affect local visibility. Other examples of secondary environmental impacts could include hazardous waste discharges, such as spent catalysts or contaminated carbon. Generally, these types of environmental concerns become important when sensitive site-specific receptors exist or when the incremental emissions reduction potential of the top control is only marginally greater than the next most effective option. However, the fact that a control device creates liquid and solid waste that must be disposed of does not necessarily argue against selection of that technology as BACT, particularly if the control device has been applied to similar facilities elsewhere and the solid or liquid waste problem under review is not significantly greater than in those other applications. On the other hand, where the applicant can show that unusual circumstances at the proposed facility create greater problems than experienced elsewhere, this may provide a basis for the elimination of that control alternative as BACT.

The procedure for conducting an analysis of environmental impacts should be made based on a consideration of site-specific circumstances. In general, however, the analysis of environmental impacts starts with the identification and quantification of the solid, liquid, and gaseous discharges from the control device or devices under review. This analysis of environmental impacts should be performed for the entire hierarchy of technologies even if the applicant proposes to adopt the "top", or most stringent, alternative). However, the analysis need only address those control alternatives with any significant or unusual environmental impacts that have the potential to affect the selection or elimination of a control alternative. Thus, the relative environmental impacts (both positive and negative) of the various alternatives can be compared with each other and the "top" alternative.

Initially, a qualitative or semi-quantitative screening is performed to narrow the analysis to discharges with potential for causing adverse environmental effects. Next, the mass and composition of any such discharges should be assessed and quantified to the extent possible, based on readily available information. Pertinent information about the public or environmental consequences of releasing these materials should also be assembled.

V.D.3.a. EXAMPLES (Environmental Impacts)

The following paragraphs discuss some possible factors for considerations in evaluating the potential for an adverse other media impact.

o *Water Impact*

Relative quantities of water used and water pollutants produced and discharged as a result of use of each alternative emission control system relative to the "top" alternative would be identified. Where possible, the analysis would assess the effect on ground water and such local surface water quality parameters as ph, turbidity, dissolved oxygen, salinity, toxic chemical levels, temperature, and any other important considerations. The analysis should consider whether applicable water quality standards will be met and the availability and effectiveness of various techniques to reduce potential adverse effects.

o *Solid Waste Disposal Impact*

The quality and quantity of solid waste (e.g., sludges, solids) that must be stored and disposed of or recycled as a result of the application of each alternative emission control system would be compared with the quality and quantity of wastes created with the "top" emission control system. The composition and various other characteristics of the solid waste (such as permeability, water retention, rewatering of dried material, compression strength, leachability of dissolved ions, bulk density, ability to support vegetation growth and hazardous characteristics) which are significant with regard to potential surface water pollution or transport into and contamination of subsurface waters or aquifers would be appropriate for consideration.

o *Irreversible or Irretrievable Commitment of Resources*

The BACT decision may consider the extent to which the alternative emission control systems may involve a trade-off between short-term environmental gains at the expense of long-term environmental losses and the extent to which the alternative systems may result in irreversible or irretrievable commitment of resources (for example, use of scarce water resources).

o *Other Environmental Impacts*

Significant differences in noise levels, radiant heat, or dissipated static electrical energy may be considered.

One environmental impact that could be examined is the trade-off between emissions of the various pollutants resulting from the application of a specific control technology. The use of certain control technologies may lead to increases in emissions of pollutants other than those the technology was designed to control. For example, the use of certain volatile organic compound (VOC) control technologies can increase nitrogen oxides ($NO_x$) emissions. In this instance, the reviewing authority may want to give consideration to any relevant local air quality concern relative to the secondary pollutant (in this case $NO_x$) in the region of the proposed source. For example, if the region in the example were nonattainment for $NO_x$, a premium could be placed on the potential $NO_x$ impact. This could lead to elimination of the most stringent VOC technology (assuming it generated high quantities of $NO_x$) in favor of one having less of an impact on ambient $NO_x$ concentrations. Another example is the potential for higher emissions of toxic and hazardous pollutants from a municipal waste combustor operating at a low flame temperature to reduce the formation of $NO_x$. In this case the real concern to mitigate the emissions of toxic and hazardous emissions (via high combustion temperatures) may well take precedent over mitigating $NO_x$ emissions through the use of a low flame temperature. However, in most cases (unless an overriding concern over the formation and impact of the secondary pollutant is clearly present as in the examples given), it is not expected that this type impact would affect the outcome of the decision.

Other examples of collateral environmental impacts would include hazardous waste discharges such as spent catalysts or contaminated carbon. Generally these types of environmental concerns become important when site-specific sensitive receptors exist or when the incremental emissions reduction potential of the top control option is only marginally greater than the next most effective option.

## V.D.3.b. CONSIDERATION OF EMISSIONS OF TOXIC AND HAZARDOUS AIR POLLUTANTS

The generation or reduction of toxic and hazardous emissions, including compounds not regulated under the Clean Air Act, are considered as part of the environmental impacts analysis. Pursuant to the EPA Administrator's decision in North County Resource Recovery Associates, PSD Appeal No. 85-2 (Remand Order, June 3, 1986), a PSD permitting authority should consider the effects of a given control alternative on emissions of toxics or hazardous pollutants not regulated under the Clean Air Act. The ability of a given control alternative to control releases of unregulated toxic or hazardous emissions must be evaluated and may, as appropriate, affect the BACT decision. Conversely, hazardous or toxic emissions resulting from a given control technology should also be considered and may, as appropriate, also affect the BACT decision.

Because of the variety of sources and pollutants that may be considered in this assessment, it is not feasible for the EPA to provide highly detailed national guidance on performing an evaluation of the toxic impacts as part of the BACT determination. Also, detailed information with respect to the type and magnitude of emissions of unregulated pollutants for many source categories is currently limited. For example, a combustion source emits hundreds of substances, but knowledge of the magnitude of some of these emissions or the hazards they produce is sparse. While the EPA is pursuing a variety of projects that will help permitting authorities to determine pollutants of concern, EPA believes it is appropriate for agencies to proceed on a case-by-case basis using the best information available. Thus, the determination of whether the pollutants would be emitted in amounts sufficient to be of concern is one that the permitting authority has considerable discretion in making. However, reasonable efforts should be made to address these issues. For example, such efforts might include consultation with the:

- o EPA Regional Office;
- o Control Technology Center (CTC);
- o National Air Toxics Information Clearinghouse;
- o Air Risk Information Support Center in the Office of Air Quality Planning and Standards (OAQPS); and
- o review of the literature, such as: EPA-prepared compilations of emission factors.

Source-specific information supplied by the permit applicant is often the best source of information, and it is important that the applicant be made aware of its responsibility to provide for a reasonable accounting of air toxics emissions.

Similarly, once the pollutants of concern are identified, the permitting authority has flexibility in determining the methods by which it factors air toxics considerations into the BACT determination, subject to the obligation to make reasonable efforts to consider air toxics. Consultation by the review authority with EPA's implementation centers, particularly the CTC, is again advised.

It is important to note that several acceptable methods, including risk assessment, exist to incorporate air toxics concerns into the BACT decision. The depth of the toxics assessment will vary with the circumstances of the particular source under review, the nature and magnitude of the toxic pollutants, and the locality. Emissions of toxic or hazardous pollutant of concern to the permit agency should be identified and, to the extent possible, quantified. In addition, the effectiveness of the various control alternatives in the hierarchy at controlling the toxic pollutant should be estimated and summarized to assist in making judgements about how potential emissions of toxic or hazardous pollutants may be mitigated through the selection of one control option over another.

Under a top-down BACT analysis, the control alternative selected as BACT will most likely reduce toxic emissions as well as the regulated pollutant. An example is the emissions of heavy metals typically associated with coal combustion. The metals generally are a portion of, or adsorbed on, the fine particulate in the exhaust gas stream. Collection of the particulate in a high efficiency fabric filter rather than a low efficiency electrostatic precipitator reduces criteria pollutant particulate matter emissions and toxic heavy metals emissions. Because in most instances the interests of reducing toxics coincide with the interests of reducing the pollutants subject to BACT, consideration of toxics in the BACT analysis generally amounts to quantifying toxic emission levels for the various control options.

In limited other instances, though, control of regulated pollutant emissions may compete with control of toxic compounds, as in the case of certain selective catalytic reduction (SCR) $NO_x$ control technologies. The SCR technology itself results in emissions of ammonia, which increase, generally speaking, with increasing levels of $NO_x$ control. It is the intent of the toxics screening in the BACT procedure to identify and quantify this type of toxic effect. Generally, toxic effects of this type will not necessarily be overriding concerns and will likely not to affect BACT decisions. Rather, the intent is to require a screening of toxics emissions effects to ensure that a possible overriding toxics issue does not escape notice.

On occasion, consideration of toxics emissions may support the selection of a control technology that yields less than the maximum degree of reduction in emissions of the regulated pollutant in question. An example is the municipal solid waste combustor and resource recovery facility that was the subject of the North County remand. Briefly, BACT for $SO_2$ and PM was selected to be a lime slurry spray drier followed by a fabric filter. The combination yields good $SO_2$ control (approximately 83 percent), good PM control (approximately 99.5 percent) and also removes acid gases (approximately 95 percent), metals, dioxins, and other unregulated pollutants. In this instance, the permitting authority determined that good balanced control of regulated and unregulated pollutants took priority over achieving the maximum degree of emissions reduction for one or more regulated pollutants. Specifically, higher levels (up to 95 percent) of $SO_2$ control could have been obtained by a wet scrubber.

## V.E. SELECTING BACT (STEP 5)

The most effective control alternative not eliminated in Step 4 is selected as BACT.

It is important to note that, regardless of the control level proposed by the applicant as BACT, the ultimate BACT decision is made by the permit issuing agency after public review. The applicant's role is primarily to provide information on the various control options and, when it proposes a less stringent control option, provide a detailed rationale and supporting documentation for eliminating the more stringent options. It is the responsibility of the permit agency to review the documentation and rationale presented and; (1) ensure that the applicant has addressed all of the most effective control options that could be applied and; (2) determine that the applicant has adequately demonstrated that energy, environmental, or economic impacts justify any proposal to eliminate the more effective control options. Where the permit agency does not accept the basis for the proposed elimination of a control option, the agency may inform the applicant of the need for more information regarding the control option. However, the BACT selection essentially should default to the highest level of control for which the applicant could not adequately justify its elimination based on energy, environmental and economic impacts. If the applicant is unable to provide to the permit agency's satisfaction an adequate demonstration for one or more control alternatives, the permit agency should proceed to establish BACT and prepare a draft permit based on the most effective control option for which an adequate justification for rejection was not provided.

## V.F. OTHER CONSIDERATIONS

Once energy, environmental, and economic impacts have been considered, BACT can only be made more stringent by other considerations outside the normal scope of the BACT analysis as discussed under the above steps. Examples include cases where BACT does not produce a degree of control stringent enough to prevent exceedences of a national ambient air quality standard or PSD increment, or where the State or local agency will not accept the level of control selected as BACT and requires more stringent controls to preserve a greater amount of the available increment. A permit cannot be issued to a source that would cause or contribute to such a violation, regardless of the outcome of the BACT analysis. Also, States which have set ambient air quality standards at levels tighter than the federal standards may demand a more stringent level of control at a source to demonstrate compliance with the State standards. Another consideration which could override the selected BACT are legal constraints outside of the Clean Air Act requiring the application of a more stringent technology (e.g., a consent decree requiring a greater degree of control). In all cases, regardless of the rationale for the permit requiring a more stringent emissions limit than would have otherwise been chosen as a result of the BACT selection process, the emission limit in the final permit (and corresponding control alternative) represents BACT for the permitted source on a case-by-case basis.

The BACT emission limit in a new source permit is not set until the final permit is issued. The final permit is not issued until a draft permit has gone through public comment and the permitting agency has had an opportunity to consider any new information that may have come to light during the comment period. Consequently, in setting a proposed or final BACT limit, the permit agency can consider new information it learns, including recent permit decisions, subsequent to the submittal of a complete application. This emphasizes the importance of ensuring that prior to the selection of a proposed BACT, all potential sources of information have been reviewed to ensure that the list of potentially applicable control alternatives is complete (most importantly as it relates to any more effective control options than the one chosen) and that all considerations relating to economic, energy and environmental impacts have been addressed. These responsibilities reside with the applicant.

## VI. ENFORCEABILITY OF BACT

To complete the BACT process, the reviewing agency must establish an enforceable emission limit for each emission unit at the source and for each pollutant subject to review that is emitted from the source. If technological or economic limitations in the application of a measurement methodology to a particular emission unit would make an emissions limit infeasible, a design, equipment, work practice, operation standard, or combination thereof, may be prescribed. Also, the technology upon which the BACT emissions limit is based should be specified in the permit. These requirements should be written in the permit so that they are specific to the individual emission unit(s) subject to PSD review.

The emissions limits must be included in the proposed permit submitted for public comment, as well as the final permit. BACT emission limits or conditions must be met on a continual basis at all levels of operation (e.g., limits written in pounds/MMbtu or percent reduction achieved), demonstrate protection of short term ambient standards (limits written in pounds/hour) and be enforceable as a practical matter (contain appropriate averaging times, compliance verification procedures and recordkeeping requirements). Consequently, the permit must:

- be able to show compliance or noncompliance (i.e., through monitoring times of operation, fuel input, or other indices of operating conditions and practices); and

- specify a reasonable averaging time consistent with established reference methods, contain reference methods for determining compliance, and provide for adequate reporting and recordkeeping so that the permitting agency can determine the compliance status of the source.

# VII. EXAMPLE BACT ANALYSES FOR GAS TURBINES

***Note: The following example provided is for illustration only. The example source is fictitious and has been created to highlight many of the aspects of the top-down process. Finally, it must be noted that the cost data and other numbers presented in the example are used only to demonstrate the BACT decision making process. Cost data are used in a relative sense to compare control costs among sources in a source category or for a pollutant. No absolute cost guidelines have been established above which costs are assumed to be too high or below which they are assumed reasonable. Determination of appropriate costs is made on a case-by-case basis.***

In this section a BACT analysis for a stationary gas turbine project is presented and discussed under three alternative operating scenarios:

- o Example 1--Simple Cycle Gas Turbines Firing Natural Gas
- o Example 2--Combined Cycle Gas Turbines Firing Natural Gas
- o Example 3--Combined Cycle Gas Turbines Firing Distillate Oil

The purpose of the examples are to illustrate points to be considered in developing BACT decision criteria for the source under review and selecting BACT. They are intended to illustrate the <u>process</u> rather than provide universal guidance on what constitutes BACT for any particular source category. BACT must be determined on a case-by-case basis.

These examples are not based on any actual analyses performed for the purposes of obtaining a PSD permit. Consequently, the actual emission rates, costs, and design parameters used are neither representative of any actual case nor do they apply to any particular facility.

## VII.A. EXAMPLE 1--SIMPLE CYCLE GAS TURBINES FIRING NATURAL GAS

### VII.A.1 PROJECT SUMMARY

Table VII-1 presents project data, stationary gas design parameters, and uncontrolled emission estimates for the new source in example 1. The gas turbine is designed to provide peaking service to an electric utility. The planned operating hours are less than 1000 hours per year. Natural gas fuel will be fired. The source will be limited through enforceable conditions to the specified hours of operation and fuel type. The area where the source is to be located is in compliance for all criteria pollutants. No other changes are proposed at this facility, and therefore the net emissions change will be equal to the emissions shown on Table VII-1. Only $NO_x$ emissions are significant (i.e., greater than the 40 tpy significance level for $NO_x$) and a BACT analysis is required for $NO_x$ emissions only.

### VII.A.2. BACT ANALYSIS SUMMARY

#### VII.A.2.a. CONTROL TECHNOLOGY OPTIONS

The first step in evaluating BACT is identifying all candidate control technology options for the emissions unit under review. Table VII-2 presents the list of control technologies selected as potential BACT candidates. The first three control technologies, wet injection and selective catalytic reduction, were identified by a review of existing gas turbine facilities in operation. Wet injection can mean either water or steam injection. Selective noncatalytic reduction was identified as a potential type of control technology because it is an add-on $NO_x$ control which has been applied to other types of combustion sources.

In this example, the control technologies were identified by the applicant based on a review of the BACT/LAER Clearinghouse, and discussions with State agencies with experience permitting gas turbines in $NO_x$ nonattainment areas. A preliminary meeting with the State permit issuing agency was held to determine whether the permitting agency felt that any other

## TABLE VII-1. EXAMPLE 1--COMBUSTION TURBINE DESIGN PARAMETERS

| Characteristics | |
|---|---|
| Number of emissions units | 1 |
| Unit Type | Gas Turbines |
| Cycle Type | Simple-cycle |
| Output | 75 MW |
| Exhaust temperature, | 1,000 °F |
| Fuel(s) | Natural Gas |
| Heat rate, Btu/kw hr | 11,000 |
| Fuel flow, Btu/hr | 1,650 million |
| Fuel flow, lb/hr | 83,300 |
| Service Type | Peaking |
| Operating Hours (per year) | 1,000 |
| Uncontrolled Emissions, tpy(a) | |
| $NO_x$ | 564 (169 ppm) |
| $SO_2$ | <1 |
| CO | 4.6 (6 ppm) |
| VOC | 1 |
| PM | 5 (0.0097 gr/dscf) |

(a) Based on 1000 hours per year of operation at full load.

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## TABLE VII-2. EXAMPLE 1--SUMMARY OF POTENTIAL NOx CONTROL TECHNOLOGY OPTIONS

| Control technology(a) | Typical control efficiency range (% reduction) | In Service On: Simple cycle turbines | Combined cycle gas turbines | Other combustion sources(c) | Technically feasible on simple cycle turbines |
|---|---|---|---|---|---|
| Selective Catalytic Reductions | 40-90 | No | Yes | Yes | Yes(b) |
| Water Injection | 30-70 | Yes | Yes | Yes | Yes |
| Steam Injection | 30-70 | No | Yes | Yes | No |
| Low NOx Burner | 30-70 | Yes | Yes | Yes | Yes |
| Selective Noncatalytic Reduction | 20-50 | No | Yes | Yes | No |

(a) Ranked in order of highest to lowest stringency.
(b) Exhaust must be diluted with air to reduce its temperature to 600-750°F.
(c) Boiler incinerators, etc.

applicable control technologies should be evaluated and they agreed on the proposed control hierarchy.

## VII.A.2.b. TECHNICAL FEASIBILITY CONSIDERATIONS

Once potential control technologies have been identified, each technology is evaluated for its technical feasibility based on the characteristics of the source. Because the gas turbines in this example are intended to be used for peaking service, a heat recovery steam generator (HRSG) will not be included. A HRSG recovers heat from the gas turbine exhaust to make steam and increase overall energy efficiency. A portion of the steam produced can be used for steam injection for $NO_x$ control, sometimes increasing the effectiveness of the net injection control system. However, the electrical demands of the grid dictate that the turbine will be brought on line only for short periods of time to meet peak demands. Due to the lag time required to bring a heat recovery steam generator on line, it is not technically feasible to use a HRSG at the facility. Use of an HRSG in this instance was shown to interfere with the performance of the unit for peaking service, which requires immediate response times for the turbine. Although it was shown that a HRSG was not feasible, water and steam are readily available for $NO_x$ control since the turbine will be located near an existing steam generating powerplant.

The turbine type and, therefore, the turbine model selection process, affects the achievability of $NO_x$ emissions limits. Factors which the customer considered in selecting the proposed turbine model were outlined in the application as: the peak demand which must be met, efficiency of the gas turbine, reliability requirements, and the experience of the utility with the operation and maintenance service of the particular manufacturer and turbine design. In this example, the proposed turbine is equipped with a combustor designed to achieve an emission level, at 15 percent $O_2$, of 25 ppm $NO_x$ with steam injection or 42 ppm with water injection.[1]

Selective noncatalytic reduction (SNCR) was eliminated as technically infeasible because this technology requires a flue gas temperature of 1300 to 2100°F. The exhaust from the gas turbines will be approximately 1000°F, which is below the required temperature range.

Selective catalytic reduction (SCR) was evaluated and no basis was found to eliminate this technology as technically infeasible. However, there are no known examples where SCR technology has been applied to a simple-cycle gas turbine or to a gas turbine in peaking service. In all cases where SCR has been applied, there was an HRSG which served to reduce the exhaust temperature to the optimum range of 600-750°F and the gas turbine was operated continuously. Consequently, application of SCR to a simple cycle turbine involves special circumstances. For this example, it is assumed that dilution air can be added to the gas turbine exhaust to reduce its temperature. However, the dilution air will make the system more costly due to higher gas flows, and may reduce the removal efficiency because the $NO_x$ concentration at the inlet will be reduced. Cost considerations are considered later in the analysis.

### VII.A.2.c. CONTROL TECHNOLOGY HIERARCHY

After determining technical feasibility, the applicant selected the control levels for evaluation shown in Table VII-3. Although the applicant reported that some sites in California have achieved levels as low as 9 ppm, at this facility a 13 ppm level was determined to be the feasible limit with SCR. This decision is based on the lowest achievable level with steam injection of 25 ppm and an SCR removal efficiency of 50 percent. Even though

[1] For some gas turbine models, 25 ppm is not achievable with either water or steam injection.

TABLE VII-3. EXAMPLE 1--CONTROL TECHNOLOGY HIERARCHY

| Control Technology | Emissions Limits ppm(a) | TPY |
|---|---|---|
| Steam Injection plus SCR | 13 | 44 |
| Steam Injection at maximum(b) design rate | 25 | 84 |
| Water Injection at maximum(b) design rate | 42 | 140 |
| Steam Injection to meet NSPS | 93 | 312 |

(a) Corrected to 15 percent oxygen.

(b) Water to fuel ratio.

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the reported removal efficiencies for SCR are up to 90 percent at some facilities, at this facility the actual $NO_x$ concentration at the inlet to the SCR system will only be approximately 17 ppm (at actual conditions) due to the dilution air required. Also the inlet concentrations, flowrates, and temperatures will vary due to the high frequency of startups. These factors make achieving the optimum 90 percent $NO_x$ removal efficiency unrealistic. Based on discussions with SCR vendors, the applicant has established a 50 percent removal efficiency as the highest level achievable, thereby resulting in a 13 ppm level (i.e., 50 percent of 25 ppm).

The next most stringent level achievable would be steam injection at the maximum water-to-fuel ratio achievable by the unit within its design operating range. For this particular gas turbine model, that level is 25 ppm as supported by vendor $NO_x$ emissions guarantees and unit test data. The applicant provided documentation obtained from the gas turbine manufacturer[2] verifying ability to achieve this range.

After steam injection the next most stringent level of control would be water injection at the maximum water-to-fuel ratio achievable by the unit within its design operating range. For this particular gas turbine model, that level is 42 ppm as supported by vendor $NO_x$ emissions guarantees and actual unit test data. The applicant provided documentation obtained from the gas turbine manufacturer verifying ability to achieve this range.

The least stringent level evaluated by the applicant was the current NSPS for utility gas turbines. For this model, that level is 93 ppm at 15 percent $O_2$. By definition, BACT can be no less stringent than NSPS. Therefore, less stringent levels are not evaluated.

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[2] It should be noted that achievability of the $NO_x$ limits is dependent on the turbine model, fuel, type of wet injection (water or steam), and system design. Not all gas turbine models or fuels can necessarily achieve these levels.

### VII.A.2.d. IMPACTS ANALYSIS SUMMARY

The next steps completed by the applicant were the development of the cost, economic, environmental and energy impacts of the different control alternatives. Although the top-down process would allow for the selection of the top alternative without a cost analysis, the applicant felt cost/economic impacts were excessive and that appropriate documentation may justify the elimination of SCR as BACT and therefore chose to quantify cost and economic impacts. Because the technologies in this case are applied in combination, it was necessary to quantify impacts for each of the alternatives. The impact estimates are shown in Table VII-4. Adequate documentation of the basis for the impacts was determined to be included in the PSD permit application.

The incremental cost impacts shown are the cost of the alternative compared to the next most stringent control alternative. Figure VII-1 is a plot of the least-cost envelope defined by the list of control options.

### VII.A.2.e. TOXICS ASSESSMENT

Potential toxic emissions which could occur as a result of this facility would be ammonia if SCR were applied. Ammonia emissions resulting from application of SCR could be as large as 20 tons per year. Application of SCR would reduce $NO_x$ by an additional 20 tpy over steam injection alone (25 ppm)(not including ammonia emissions).

Another environmental impact considered was the spent catalyst which would have to be disposed of at certain operating intervals. The catalyst contains vanadium pentoxide, which is listed as a hazardous waste under RCRA regulations (40 CFR 261.3). Disposal of this waste creates an additional

TABLE VII-4. EXAMPLE 1--SUMMARY OF TOP-DOWN BACT IMPACT ANALYSIS RESULTS FOR $NO_x$

| | Emissions per Turbine | | | Economic Impacts | | | | Energy Impacts | Environmental Impacts | |
|---|---|---|---|---|---|---|---|---|---|---|
| Control alternative | Emissions (lb/hr) | (tpy) | Emissions reduction(a) (tpy) | Installed capital cost(b) ($) | Total annualized cost(c) ($/yr) | Cost effectiveness over baseline(d) ($/ton) | Incremental cost effectiveness(e) ($/ton) | Incremental increase over baseline(f) (MMBtu/yr) | Toxics impact (Yes/No) | Adverse environmental impact (Yes/No) |
| 13 ppm Alternative | 44 | 22 | 260 | 11,470,000 | 1,717,000(g) | 6,600 | 56,200 | 464,000 | Yes | No |
| 25 ppm Alternative | 84 | 42 | 240 | 1,790,000 | 593,000 | 2,470 | 8,460 | 30,000 | No | No |
| 42 ppm Alternative | 140 | 70 | 212 | 1,304,000 | 356,000 | 1,680 | 800 | 15,300 | No | No |
| NSPS Alternative | 312 | 156 | 126 | 927,000 | 288,000 | 2,285 | | 8,000 | No | No |
| Uncontrolled Baseline | 564 | 282 | - | - | - | - | - | - | - | - |

(a) Emissions reduction over baseline control level.
(b) Installed capital cost relative to baseline.
(c) Total annualized cost (capital, direct, and indirect) of purchasing, installing, and operating the proposed control alternative. A capital recovery factor approach using a real interest rate (i.e., absent inflation) is used to express capital costs in present-day annual costs.
(d) Cost Effectiveness over baseline is equal to total annualized cost for the control option divided by the emissions reductions resulting from the uncontrolled baseline.
(e) The optional incremental cost effectiveness criteria is the same as the total cost effectiveness criteria except that the control alternative is considered relative to the next most stringent alternative rather than the baseline control alternative.
(f) Energy impacts are the difference in total project energy requirements with the control alternative and the baseline control alternative expressed in equivalent millions of Btus per year.
(g) Assued 10 year catalyst life since this turbine operates only 1000 hours per year. Assumptions made on catalyst life may have a profound affect upon cost effectiveness.



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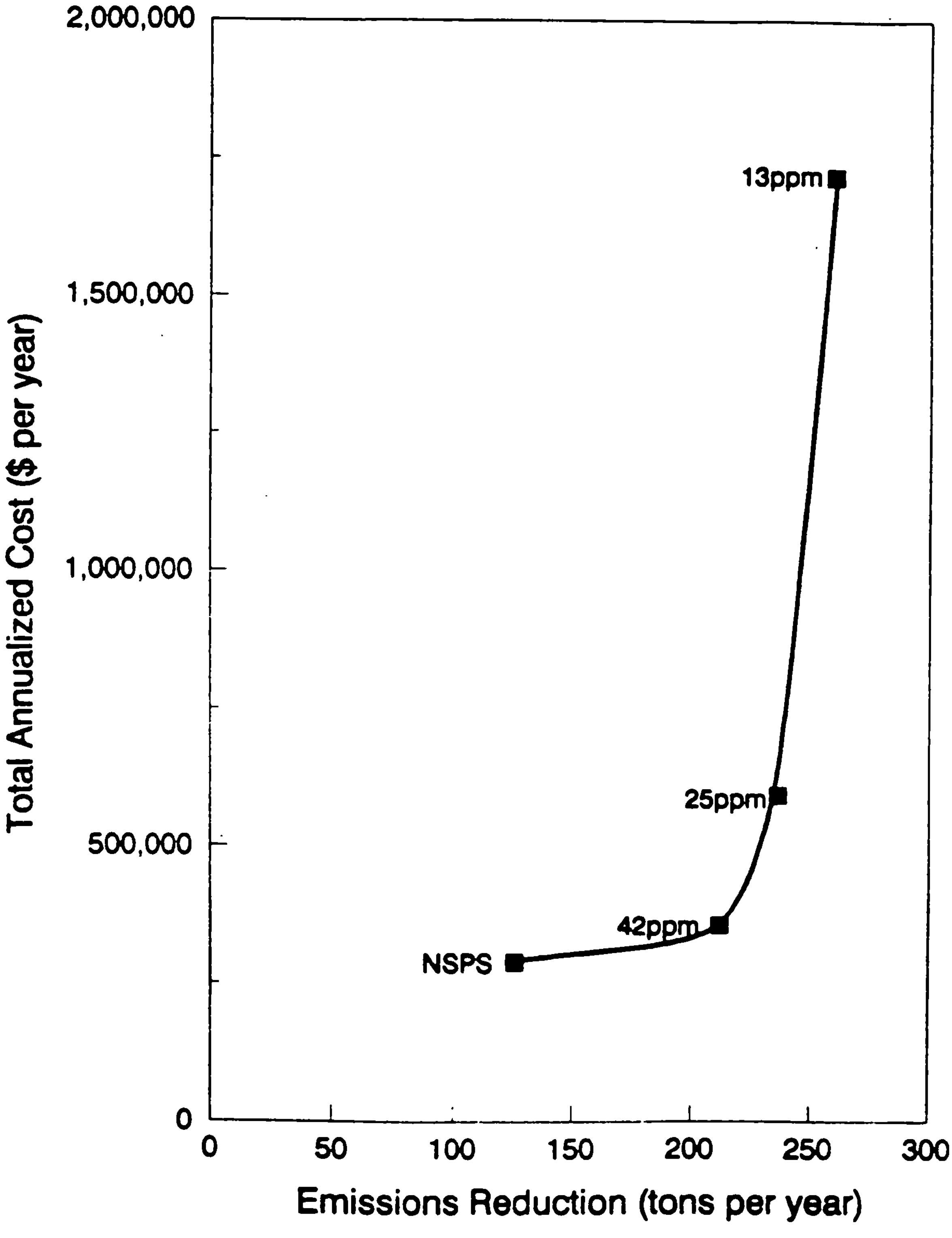
Figure VII-1. Least-Cost Envelope for Example 1



economic and environmental burden. This was considered in the applicant's proposed BACT determination.

## VII.A.2.f. RATIONALE FOR PROPOSED BACT

Based on these impacts, the applicant proposed eliminating the 13 ppm alternative as economically infeasible. The applicant documented that the cost effectiveness is high at 6,600 $/ton, and well out of the range of recent BACT $NO_x$ control costs for similar sources. The incremental cost effectiveness of $56,200 also is high compared to the incremental cost effectiveness of the next option.

The applicant documented that the other combustion turbine sources which have applied SCR have much higher operating hours (i.e., all were permitted as base-loaded units). Also, these sources had heat recovery steam generators so that the cost effectiveness of the application of SCR was lower. For this source, dilution air must be added to cool the flue gas to the proper temperature. This increases the cost of the SCR system relative to the same gas turbine with a HRSG. Therefore, the other sources had much lower cost impacts for SCR relative to steam injection alone, and much lower cost effectiveness numbers. Application of SCR would also result in emission of ammonia, a toxic chemical, of possibly 20 tons per year while reducing $NO_x$ emissions by 20 tons per year. The applicant asserted that, based on these circumstances, to apply SCR in this case would be an unreasonable burden compared to what has been done at other similar sources.

Consequently, the applicant proposed eliminating the SCR plus steam injection alternative. The applicant then accepted the next control alternative, steam injection to 25 ppmv. The review authority concurred with the proposed elimination of SCR and the selection of a 25 ppmv limit as BACT.

## VII.B. EXAMPLE 2--COMBINED CYCLE GAS TURBINES FIRING NATURAL GAS

Table VII-5 presents the design parameters for an alternative set of circumstances. In this example, two gas turbines are being installed. Also, the operating hours are 5000 per year and the new turbines are being added to meet intermediate loads demands. The source will be limited through enforceable conditions to the specified hours of operation and fuel type. In this case, HRSG units are installed. The applicable control technologies and control technology hierarchy are the same as the previous example except that no dilution is required for the gas turbine exhaust because the HRSG serves to reduce the exhaust temperature to the optimum level for SCR operation. Also, since there is no dilution required and fewer startups, the most stringent control option proposed is 9 ppm based on performance limits for several other natural gas fired baseload combustion turbine facilities.

Table VII-6 presents the results of the cost and economic impact analysis for the example and Figure VII-2 is a plot of the least-cost envelope defined by the list of control options. The incremental cost impacts shown are the cost of the alternative compared to the next most stringent control alternative. Due to the increased operating hours and design changes, the economic impacts of SCR are much lower for this case. There does not appear to be a persuasive argument for stating that SCR is economically infeasible. Cost effectiveness numbers are within the range typically required of this and other similar source types.

In this case, there would also be emissions of ammonia. However, now the magnitude of ammonia emissions, approximately 40 tons per year, is much lower than the additional $NO_x$ reduction achieved, which is 270 tons per year.

Under these alternative circumstances, PM emissions are also now above the significance level (i.e., greater than 25 tpy). The gas turbine

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TABLE VII-5. EXAMPLE 2--COMBUSTION TURBINE DESIGN PARAMETERS

| Characteristics | |
|---|---|
| Number of emission units | 2 |
| Emission units | Gas Turbine |
| Cycle Type | Combined-cycle |
| Output | |
| Gas Turbines (2 @ 75 MW each) | 150 MW |
| Steam Turbine (no emissions generated) | 70 MW |
| Fuel(s) | Natural Gas |
| Gas Turbine Heat Rate, Btu/kw-hr | 11,000 Btu/kw-hr |
| Fuel Flow per gas turbine, Btu/hr | 1,650 million |
| Fuel Flow per gas turbine, lb/hr | 83,300 |
| Service Type | Intermediate |
| Hours per year of operation | 5000 |
| Uncontrolled Emissions per gas turbine, tpy (a)(b) | |
| $NO_x$ | 1,410 (169 ppm) |
| $SO_2$ | <1 |
| CO | 23 (6 ppm) |
| VOC | 5 |
| PM | 25 (0.0097 gr/dscf) |

(a) Based on 5000 hours per year of operation.

(b) Total uncontrolled emissions for the proposed project is equal to the pollutants uncontrolled emission rate multiplied by 2 turbines. For example, total $NO_x$ = (2 turbines) x 1410 tpy per turbine) = 2820 tpy.

TABLE VII-6. EXAMPLE 2--SUMMARY OF TOP-DOWN BACT IMPACT ANALYSIS RESULTS FOR $NO_x$

| Control alternative | Emissions per Turbine: Emissions (lb/hr) | Emissions per Turbine: (tpy) | Emissions per Turbine: Emissions reduction(a,h) (tpy) | Economic Impacts: Installed capital cost(b) ($) | Economic Impacts: Total annualized cost(c) ($/yr) | Economic Impacts: Cost effectiveness over baseline(d) ($/ton) | Economic Impacts: Incremental cost effectiveness(e) ($/ton) | Energy Impacts: Incremental increase over baseline(f) (MMBtu/yr) | Environmental Impacts: Toxics impact (Yes/No) | Environmental Impacts: Adverse environmental impact (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 ppm Alternative | 30 | 75 | 1,335 | 10,980,000 | 3,380,000(g) | 2,531 | 12,200 | 160,000 | Yes | No |
| 25 ppm Alternative | 84 | 210 | 1,200 | 1,791,000 | 1,730,000 | 1,440 | 6,050 | 105,000 | No | No |
| 42 ppm Alternative | 140 | 350 | 1,060 | 1,304,000 | 883,000 | 833 | 181 | 57,200 | No | No |
| NSPS Alternative | 312 | 780 | 630 | 927,000 | 805,000 | 1,280 | | 27,000 | No | No |
| Uncontrolled Baseline | 564 | 1,410 | - | - | - | - | - | - | - | - |

(a) Emissions reduction over baseline control level.
(b) Installed capital cost relative to baseline.
(c) Total annualized cost (capital, direct, and indirect) of purchasing, installing, and operating the proposed control alternative. A capital recovery factor approach using a real interest rate (i.e., absent inflation) is used to express capital costs in present-day annual costs.
(d) Cost Effectiveness over baseline is equal to total annualized cost for the control option divided by the emissions reductions resulting from the uncontrolled baseline.
(e) The optional incremental cost effectiveness criteria is the same as the total cost effectiveness criteria except that the control alternative is considered relative to the next most stringent alternative rather than the baseline control alternative.
(f) Energy impacts are the difference in total project energy requirements with the control alternative and the baseline control alternative expressed in equivalent millions of Btus per year.
(g) Assumes a 2 year catalyst life. Assumptions made on catalyst life may have a profound affect upon cost effectiveness.
(h) Since the project calls for two turbines, actual project wide emissions reductions for an alternative will be equal to two times the reduction listed.

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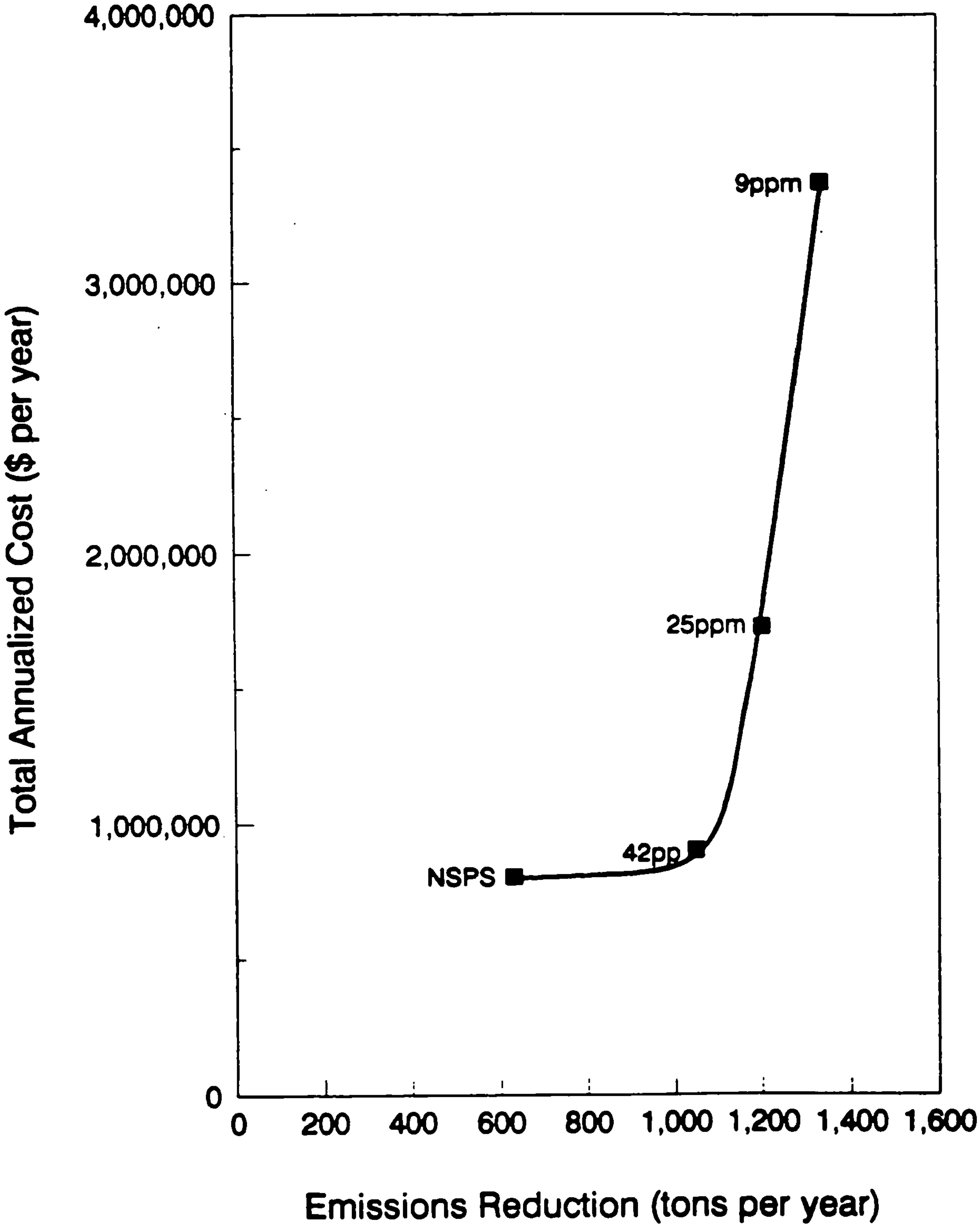
Figure VII-2. Least-Cost Envelope for Example 2



combustors are designed to combust the fuel as completely as possible and therefore reduce PM to the lowest possible level. Natural gas contains no solids and solids are removed from the injected water. The PM emission rate without add-on controls is on the same order (0.009 gr/dscf) as that for other particulate matter sources controlled with stringent add-on controls (e.g., fabric filter). Since the applicant documented that precombustion or add-on controls for PM have never been required for natural gas fired turbines, the reviewing agency accepted the applicants analysis that natural gas firing was BACT for PM emissions and that no additional analysis of PM controls was required.

## VII.C. EXAMPLE 3--COMBINED CYCLE GAS TURBINE FIRING DISTILLATE OIL

In this example, the same combined cycle gas turbines are proposed except that distillate oil is fired rather than natural gas. The reason is that natural gas is not available on site and there is no pipeline within a reasonable distance. The fuel change raises two issues; the technical feasibility of SCR in gas turbines firing sulfur bearing fuel, and $NO_x$ levels achievable with water injection while firing fuel oil.

In this case the applicant proposed to eliminate SCR as technically infeasible because sulfur present in the fuel, even at low levels, will poison the catalyst and quickly render it ineffective. The applicant also noted that there are no cases in the U.S. where SCR has been applied to a gas turbine firing distillate oil as the primary fuel.[3]

A second issue would be the most stringent $NO_x$ control level achievable with wet injection. For oil firing the applicant has proposed 42 ppm at 15 percent oxygen. Due to flame characteristics inherent with oil firing, and limits on the amount of water or steam that can be injected, 42 ppm is the

[3] Though this argument was considered persuasive in this case, advances in catalyst technology have now made SCR with oil firing technically feasible.

lowest $NO_x$ emission level achievable with distillate oil firing. Since natural gas is not available and SCR is technically infeasible, 42 ppm is the most stringent alternative considered. Based on the cost effectiveness of wet injection, approximately 833 $/ton, there is no economic basis to eliminate the 42 ppm option since this cost is well within the range of BACT costs for $NO_x$ control. Therefore, this option is proposed as BACT.

The switch to oil from gas would also result in $SO_2$, CO, PM, and beryllium emissions above significance levels. Therefore, BACT analyses would also be required for these pollutants. These analyses are not shown in this example, but would be performed in the same manner as the BACT analysis for $NO_x$.

## VII.D. OTHER CONSIDERATIONS

The previous judgements concerning economic feasibility were in an area meeting NAAQS for both $NO_x$ and ozone. If the natural gas fired simple cycle gas turbine example previously presented were sited adjacent to a Class I area, or where air quality improvement poses a major challenge, such as next to a nonattainment area, the results may differ. In this case, even though the region of the actual site location is achieving the NAAQS, adherence to a local or regional $NO_x$ or ozone attainment strategy might result in the determination that higher costs than usual are appropriate. In such situations, higher costs (e.g., 6,600 $/ton) may not necessarily be persuasive in eliminating SCR as BACT.

While it is not the intention of BACT to prevent construction, it is possible that local or regional air quality management concerns regarding the need to minimize the air quality impacts of new sources would lead the permitting authority to require a source to either achieve stringent emission control levels or, at a minimum, that control cost expenditures meet certain cost levels without consideration of the resultant economic impact to the source.

Besides local or regional air quality concerns, other site constraints may significantly impact costs of particular control technologies. For the examples previously presented, two factors of concern are land and water availability.

The cost of the raw water is usually a small part of the cost of wet controls. However, gas turbines are sometimes located in remote locations. Though water can obviously be trucked to any location, the costs may be very high.

Land availability constraints may occur where a new source is being located at an existing plant. In these cases, unusual design and additional structural requirements could make the costs of control technologies which are commonly affordable prohibitively expensive. Such considerations may be pertinent to the calculations of impacts and ultimately the selection of BACT.

# APPENDIX A

## DEFINITION OF SELECTED TERMS

| | |
|---|---|
| BACT | Best Available Control Technology is the control level required for sources subject to PSD. From the regulation (reference 40 CFR 52.21(b)) BACT means "an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. In no event shall application of best available control technology result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard under 40 CFR Parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of best available control technology. Such standard shall, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and shall provide for compliance by means which achieve equivalent results." |
| Emission Units | The individual emitting facilities at a location that together make up the source. From the regulation (reference 40 CFR 52.21(b)), it means "any part of a stationary source which emits or would have the potential to emit any pollutant subject to regulation under the Act." |
| Increments | The maximum permissible level of air quality deterioration that may occur beyond the baseline air quality level. Increments were defined statutorily by Congress for $SO_2$ and PM. Recently EPA also has promulgated increments for $NO_x$. Increment is consumed or expanded by actual emissions changes occurring after the baseline date and by construction related actual emissions changes occurring after January 6, 1975, and February 8, 1988 for $PM/SO_2$ and $NO_x$, respectively. |

| | |
|---|---|
| Innovative Control Technology | From the regulation (reference 40 CFR 52.21(b)(19)) "Innovative control technology" means any system of air pollution control that has not been adequately demonstrated in practice, but would have a substantial likelihood of achieving greater continuous emissions reduction than any control system in current practice or of achieving at least comparable reductions at lower cost in terms of energy, economics, or nonair quality environmental impacts. Special delayed compliance provisions exist that may be applied when applicants propose innovative control techniques. |
| LAER | Lowest Achievable Emissions Rate is the control level required of a source subject to nonattainment review. From the regulations (reference 40 CFR 51.165(a)), it means for any source "the more stringent rate of emissions based on the following:<br><br>(a) The most stringent emissions limitation which is contained in the implementation plan of any State for such class or category of stationary source, unless the owner or operator of the proposed stationary source demonstrates that such limitations are not achievable; or<br><br>(b) The most strir nt emissions limitation which is achieved in practice by such class or category of stationary sources. This limitation, when applied to a modification, means the lowest achievable emissions rate of the new or modified emissions units within a stationary source. In no event shall the application of the term permit a proposed new or modified stationary source to emit any pollutant in excess of the amount allowable under an applicable new source standard of performance." |

| | |
|---|---|
| Major Modification | A major modification is a modification to an existing major stationary source resulting in a significant net emissions increase (defined elsewhere in this table) that, therefore, is subject to PSD review. From the regulation (reference 40 CFR 52.21(b)(2)):<br><br>"(i) 'Major modification' means any physical change in or change in the method of operation of a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the Act.<br><br>(ii) Any net emissions increase that is significant for volatile organic compounds shall be considered significant for ozone.<br><br>(iii) A physical change or change in the method of operation shall not include:<br><br>(a) routine maintenance, repair and replacement;<br><br>(c) use of an alternative fuel by reason of an order or rule under Section 125 of the Act;<br><br>(d) Use of an alternative fuel at a steam generating unit to the extent that the fuel is generated from municipal solid waste;<br><br>(e) Use of an alternative fuel or raw material by a stationary source which:<br><br>(1) The source was capable of accommodating before January 6, 1975, unless such change would be prohibited under any Federally enforceable permit condition which was established after January 6, 1975, pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR Subpart I or 40 CFR 51.166; or<br><br>(2) The source is approved to use under any permit issued under 40 CFR 52.21 or under regulations approved pursuant to 40 CFR 51.166;<br><br>(f) an increase in the hours of operation or in the production rate, unless such change would be prohibited under any federally enforceable permit condition which was established after January 6, 1975, pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR Subpart I or 40 CFR 51.166; or<br><br>(g) any change in ownership at a stationary source." |

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| Major Stationary Source | A major stationary source is an emissions source of sufficient size to warrant PSD review. Major modification to major stationary sources are also subject to PSD review. From the regulation (reference 40 CFR 52.21(b)(1)), (i) "Major stationary source" means:<br><br>"(a) Any of the following stationary sources of air pollutant which emits, or has the potential to emit, 100 tons per year or more of any pollutant subject to regulation under the Act: Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input, coal cleaning plants (with thermal dryers), Kraft pulp mills, Portland cement plants, primary zinc smelters, iron and steel mill plants, primary aluminum ore reduction plants, primary aluminum ore reduction plants, primary copper smelters, municipal incinerators capable of charging more than 250 tons of refuse per day, hydrofluoric, sulfuric, and nitric acid plants, petroleum refineries, lime plants, phosphate rock processing plants, coke oven batteries, sulfur recovery plants, carbon black plants (furnace process), primary lead smelters, fuel conversion plants, sintering plants, secondary metal production plants, chemical process plants, fossil fuel boilers (or combinations thereof) totaling more than 250 million British thermal units per hour heat input, petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels, taconite ore processing plants, glass fiber processing plants, and charcoal production plants;<br><br>(b) Notwithstanding the stationary source size specified in paragraph (b)(1)(i) of this section, any stationary source which emits, or has the potential to emit, 250 tons per year or more of any air pollutant subject to regulation under the Act; or<br><br>(c) Any physical change that would occur at a stationary source not otherwise qualifying under paragraph (b)(1) as a major stationary source not otherwise qualifying under paragraph (b)(1) as a major stationary source, if the changes would constitute a major stationary source by itself.<br><br>(ii) A major stationary source that is major for volatile organic compounds shall be considered major for ozone." |
| NAAQS | National Ambient Air Quality Standards are Federal standards for the minimum ambient air quality needed to protect public health and welfare. They have been set for six criteria pollutants including $SO_2$, $PM/PM_{10}$, $NO_x$, CO, $O_3$ (VOC), and Pb. |

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| NESHAP | NESHAP, or National Emission Standard for Hazardous Air Pollutants, is a technology-based standard of performance prescribed for hazardous air pollutants from certain stationary source categories under Section 112 of the Clean Air Act. Where they apply, NESHAP represent absolute minimum requirements for BACT. |
| NSPS | NSPS, or New Source Performance Standard, is an emission standard prescribed for criteria pollutants from certain stationary source categories under Section 111 of the Clean Air Act. Where they apply, NSPS represent absolute minimum requirements for BACT. |
| PSD | Prevention of significant deterioration is a construction air pollution permitting program designed to ensure air quality does not degrade beyond the NAAQS levels or beyond specified incremental amounts above a prescribed baseline level. PSD also ensures application of BACT to major stationary sources and major modifications for regulated pollutants and consideration of soils, vegetation, and visibility impacts in the permitting process. |
| Regulated Pollutants[1] | Refers to pollutants that have been regulated under the authority of the Clean Air Act (NAAQS, NSPS, NESHAP): |

$O_3$ (VOC) - Ozone, regulated through volatile organic compounds as precursors
$NO_x$ - Nitrogen oxides
$SO_2$ - Sulfur dioxide
PM (TSP) - Total suspended particulate matter
PM ($PM_{10}$) - Particulate matter with ≤10 micron aerometric diameter
CO - Carbon monoxide

| | | | |
|---|---|---|---|
| Pb | - Lead | TRS | - Total reduced sulfur (including $H_2S$) |
| As | - Asbestos | RDS | - Reduced Sulfur Compounds (including $H_2S$) |
| Be | - Beryllium | Bz | - Benzene |
| Hg | - Mercury | Rd | - Radionuclides |
| VC | - Vinyl chloride | As | - Arsenic |
| F | - Fluorides | CFC's | - Chlorofluorocarbons |
| $H_2SO_4$ | - Sulfuric acid mist | Rn-222 | - Radon-222 |
| $H_2S$ | - Hydrogen sulfide | Halons | |

[1] The referenced list of regulated pollutants is current as of November 1989. Presently, additional pollutants may also be subject to regulation under the Clean Air Act.

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**Significant Emissions Increase**

For new major stationary sources and major modifications, a significant emissions increase triggers PSD review. Review requirements must be met for each pollutant undergoing a significant net emissions increase. From the regulation (reference 40 CFR 52.21(b)(23)).

(i) "Significant" means, in reference to a net emissions increase from a modified major source or the potential of a new major source to emit any of the following pollutants, a rate of emissions that would equal or exceed any of the following rates:

Carbon monoxide: 100 tons per year (tpy)
Nitrogen oxides: 40 tpy
Sulfur dioxide: 40 tpy
Particulate matter: 25 tpy
PM10: 15 tpy
Ozone: 40 tpy of volatile organic compounds
Lead: 0.6 tpy
Asbestos: 0.007 tpy
Beryllium: 0.0004 tpy
Mercury: 0.1 tpy
Vinyl chloride: 1 tpy
Fluorides: 3 tpy
Sulfuric acid mist: 7 tpy
Hydrogen Sulfide ($H_2S$): 10 tpy
Total reduced sulfur (including $H_2S$): 10 tpy
Reduced sulfur compounds (including $H_2S$): 10 tpy

(ii) "Significant" means, in reference to a net emissions increase or the potential of a source to emit a pollutant subject to regulation under the Act, that (i) above does not list, any emissions rate.

(For example, benzene and radionuclides are pollutants falling into the "any emissions rate" category.)

(iii) Notwithstanding, paragraph (b)(23)(i) of this section, "significant means any emissions rate or any net emissions increase associated with a major stationary source or major modification which would construct within 10 kilometers of a Class I area, and have an impact on such an area equal to or greater than 1 ug/m$^3$, (24-hour average).

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| | |
|---|---|
| SIP | State Implementation Plan is the federally approved State (or local) air quality management authority's statutory plan for attaining and maintaining the NAAQS. Generally, this refers to the State/local air quality rules and permitting requirements that have been accepted by EPA as evidence of an acceptable control strategy. |
| Stationary Source | For PSD purposes, refers to all emissions units at one location under common ownership or control. From the regulation (reference 40 CFR 52.21(b)(5) and 51.166(b)(5)), it means "any building, structure, facility, or installation which emits or may emit any air pollutant subject to regulation under the Act."<br><br>"Building, structure, facility, or installation" means all of the pollutant-emitting activities which belong to the same industrial grouping, are located on one or more contiguous or adjacent properties, and are under the control of the same person (or person under common control). Pollutant-emitting activities shall be considered as part of the same industrial grouping if they belong to the same "Major Group" (i.e., which have the same first two digit code) as described in the Standard Industrial Classification Manual, 1972, as amended by the 1977 Supplement (U.S. Government Printing Office stock numbers 4101-0066 and 003-005-00176-0, respectively). |

# APPENDIX B
# ESTIMATING CONTROL COSTS

# APPENDIX B - ESTIMATING CONTROL COSTS

## I. CAPITAL COSTS

Capital costs include equipment costs, installation costs, indirect costs, and working capital (if appropriate). Figure B-1 presents the elements of total capital cost and represents a building block approach that focuses on the control device as the basic unit of analysis for estimating total capital investment. The total capital investment has a role in the determination of total annual costs and cost effectiveness.

One of the most common problems which occurs when comparing costs at different facilities is that the battery limits are different. For example, the battery limit of the cost of a electrostatic precipitation might be the precipitator itself (housing, plates, voltage regulators, transformers, etc.), ducting from the source to the precipitator, and the solids handling system. The stack would not be included because a stack will be required regardless of whether or not controls are applied. Therefore, it should be outside the battery limits of the control system.

Direct installation costs are the costs for the labor and materials to install the equipment and includes site preparation, foundations, supports, erection and handling of equipment, electrical work, piping, insulation and painting. The equipment vendor can usually supply direct installation costs.

The equipment vendor should be able to supply direct installation costs estimates or general installation costs factors. In addition, typical installation cost factors for various types of equipment are available in the following references.

- OAQPS Control Cost Manual (Fourth Edition), January 1990, EPA 450/3-90-006
- Control Technology for Hazardous Air Pollutants (HAPS) Manual, September 1986, EPA 625/6-86-014

FIGURE B-1. Elements ...otal Capital Costs

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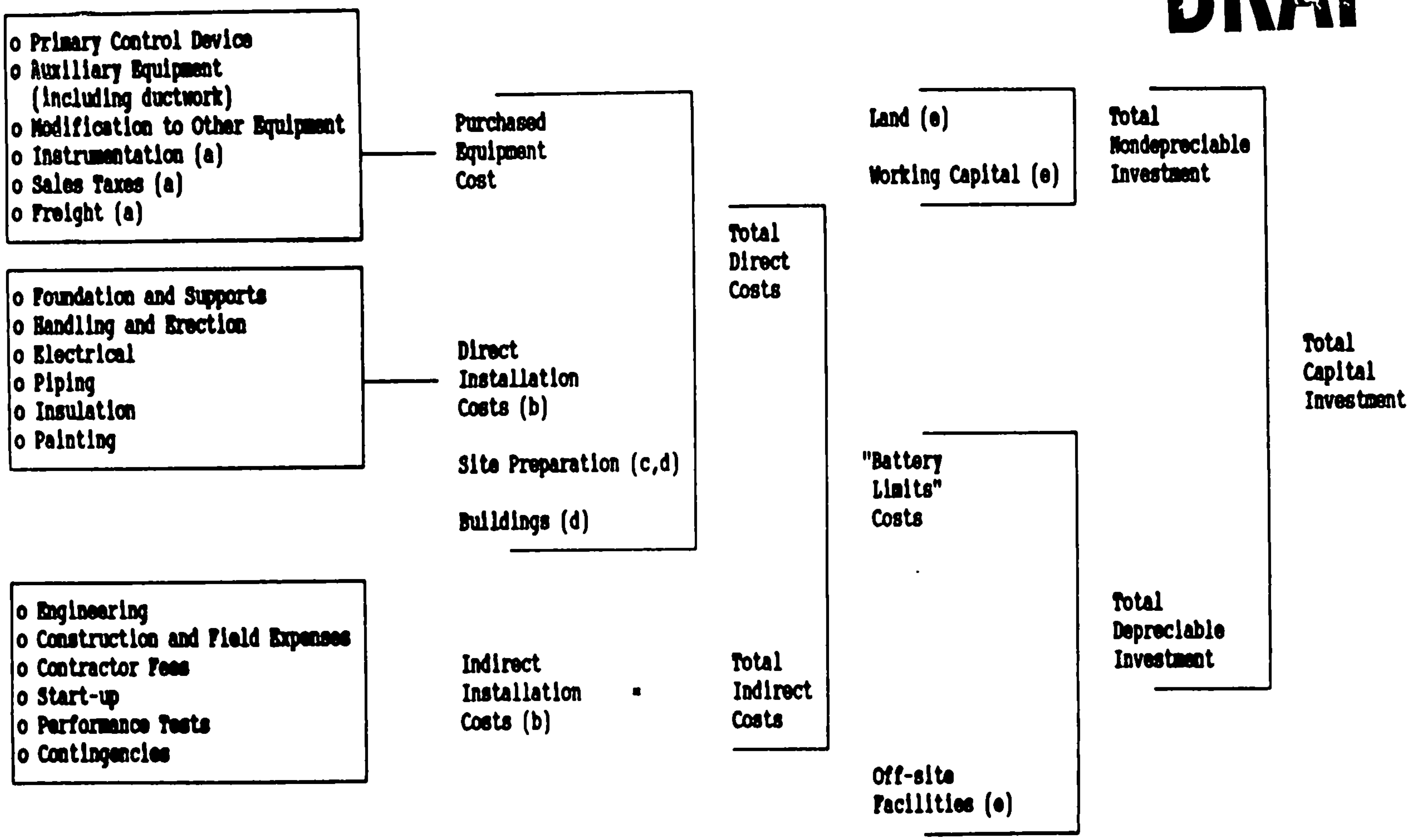


(a) These costs are factored from the sum of the control device and auxiliary equipment costs.
(b) These costs are factored from the purchased control equipment.
(c) Usually required only at "grass roots" installations.
(d) Unlike the other direct and indirect costs, costs for these items are not factored from the purchased equipment cost. Rather, they are sized and costed separately.
(e) Normally not required with add-on control systems.

- o Standards Support Documents
  - Background Information Documents
  - Control Techniques Guidelines Documents
- o Other EPA sponsored costing studies
- o Engineering Cost and Economics Textbooks
- o Other engineering cost publications

These references should also be used to validate any installation cost factors supplied from equipment vendors.

If standard costing factors are used, they may need to be adjusted due to site specific conditions. For example, in Alaska installation costs are on the order of 40 - 50 percent higher than in the contiguous 48 states due to higher labor prices, shipping costs, and climate.

Indirect installation costs include (but are not limited to) engineering, construction, start-up, performance tests, and contingency. Estimates of these costs may be developed by the applicant for the specific project under evaluation. However, if site-specific values are not available, typical estimates for these costs or cost factors are available in:

- o OAQPS Control Cost Manual (Fourth Edition), EPA 450/3-90-006
- o Cost Analysis Manual for Standards Support Documents, April 1979

These references can be used by applicants if they do not have site-specific estimates already prepared, and should also be used by the reviewing agency to determine if the applicant's estimates are reasonable. Where an applicant uses different procedures or assumptions for estimating control costs than contained in the referenced material or outlined in this document, the nature and reason for the differences are to be documented in the BACT analysis.

Working capital is a fund set aside to cover initial costs of fuel, chemicals, and other materials and other contingencies. Working capital costs for add on control systems are usually relatively small and, therefore, are usually not included in cost estimates.

Table B-1 presents an illustrative example of a capital cost estimate developed for an ESP applied to a spreader-stoker coal-fired boiler. This estimate shows the minimum level of detail required for these types of estimates. If bid costs are available, these can be used rather than study cost estimates.

## II. TOTAL ANNUAL COST.

The permit applicant should use the levelized annual cost approach for consistency in BACT cost analysis. This approach is also called the "Equivalent Uniform Annual Cost" method, or simply "Total Annual Cost" (TAC). The components of total annual costs are their relationships are shown in Figure B-2. The total annual costs for control systems is comprised of three elements: "direct" costs (DC), "indirect costs" (IC), and "recovery credit" (RC), which are related by the following equation:

$$TAC = DC + IC - RC$$

Direct costs are those which tend to be proportional or partially proportional to the quantity of exhaust gas processed by the control system or, in the case of inherently lower polluting processes, the amount of material processed or product manufactured per unit time. These include costs for raw materials, utilities (steam, electricity, process and cooling water, etc.), and waste treatment and disposal. Semivariable direct costs are only partly dependent upon the exhaust or material flowrate. These include all associated labor, maintenance materials, and replacement parts. Although these costs are a function of the operating rate, they are not linear

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TABLE B-1. EXAMPLE OF A CAPITAL COST ESTIMATE FOR AN ELECTROSTATIC PRECIPITATOR

| | Capital cost ($) |
|---|---|
| Direct Investment | |
| Equipment cost | |
| ESP unit | 175,800 |
| Ducting | 64,100 |
| Ash handling system | 97,200 |
| Total equipment cost | 337,100 |
| Installation costs | |
| ESP unit | 175,800 |
| Ducting | 102,600 |
| Ash handling system | 97,200 |
| Total installation costs | 375,600 |
| Total direct investment (TDI) (equipment + installation) | 712,700 |
| Indirect Investment | 71,300 |
| Engineering (10% of TDI) | 71,300 |
| Construction and field expenses (10% of TDI) | 71,300 |
| Construction fees (10% of TDI) | 71,300 |
| Start-up (2% of TDI) | 14,300 |
| Performance tests (minimum $2000) | 3,000 |
| Total indirect investment (TII) | 231,200 |
| Contingencies (20% of TDI + TII) | 188,800 |
| TOTAL TURNKEY COSTS (TDI + TII) | 1,132,700 |
| Working Capital (25% of total direct operating costs)a | 21,100 |
| GRAND TOTAL | 1,153,800 |

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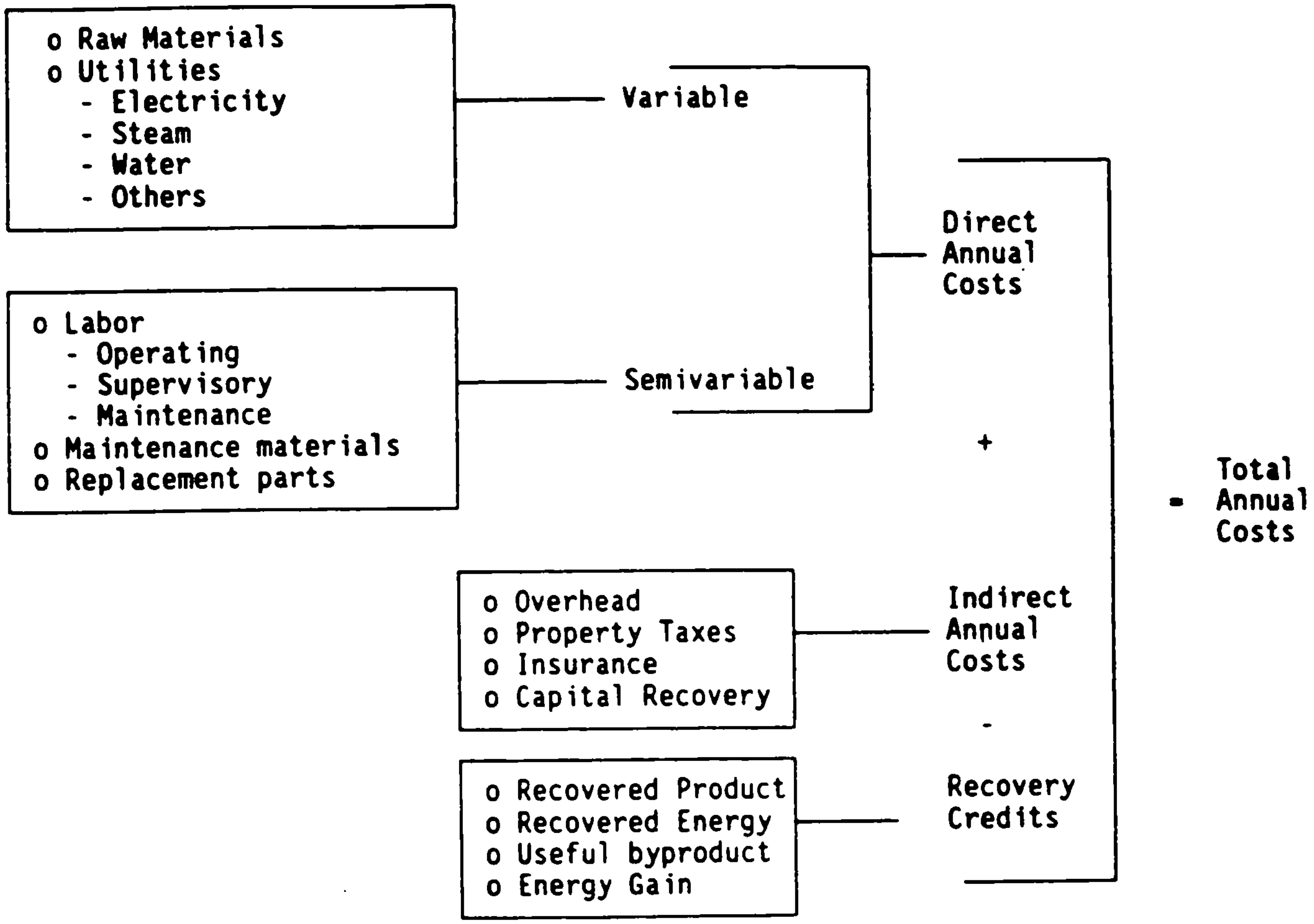
FIGURE B-2. Elements of Total Annual Costs



functions. Even while the control system is not operating, some of the semivariable costs continue to be incurred.

Indirect, or "fixed", annual costs are those whose values are relatively independent of the exhaust or material flowrate and, in fact, would be incurred even if the control system were shut down. They include such categories as overhead, property taxes, insurance, and capital recovery.

Direct and indirect annual costs are offset by recovery credits, taken for materials or energy recovered by the control system, which may be sold, recycled to the process, or reused elsewhere at the site. These credits, in turn, may be offset by the costs necessary for their purification, storage, transportation, and any associated costs required to make then reusable or resalable. For example, in auto refinishing, a source through the use of certain control technologies can save on raw materials (i.e., paint) in addition to recovered solvents. A common oversight in BACT analyses is the omission of recovery credits where the pollutant itself has some product or process value. Examples of control techniques which may produce recovery credits are equipment leak detection and repair programs, carbon absorption systems, baghouse and electrostatic precipitators for recovery of reusable or saleable solids and many inherently lower polluting processes.

Table B-2 presents an example of total annual costs for the control system previously discussed. Direct annual costs are estimated based on system design power requirements, energy balances, labor requirements, etc., and raw materials and fuel costs. Raw materials and other consumable costs should be carefully reviewed. The applicant generally should have documented delivered costs for most consumables or will be able to provide documented estimates. The direct costs should be checked to be sure they are based on the same number of hours as the emission estimates and the proposed operating schedule.

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TABLE B-2. EXAMPLE OF A ANNUAL COST ESTIMATE FOR AN ELECTROSTATIC PRECIPITATOR APPLIED TO A COAL-FIRED BOILER

| | Annual costs ($/yr) |
|---|---|
| **Direct Costs** | |
| Direct labor at $12.02/man-hour | 26,300 |
| Supervision at $15.63/man-hour | 0 |
| Maintenance labor at $14.63/man-hour | 16,000 |
| Replacement parts | 5,200 |
| Electricity at $0.0258/kWh | 3,700 |
| Water at $0.18/1000 gal | 300 |
| Waste disposal at $15/ton (dry basis) | 33,000 |
| Total direct costs | 84,500 |
| **Indirect Costs** | |
| Overhead | |
| Payroll (30% of direct labor) | 7,900 |
| Plant (26% of all labor and replacement parts) | 12,400 |
| Total overhead costs | 20,300 |
| **Capital charges** | |
| G&A taxes and insurance (4% of total turnkey costs) | 45,300 |
| Capital recovery factor (11.75% of total turnkey costs) | 133,100 |
| Interest on working capital (10% of working capital) | 2,100 |
| Total capital charges | 180,500 |
| TOTAL ANNUALIZED COSTS | 285,300 |

Maintenance costs in some cases are estimated as a percentage of the total capital investment. Maintenance costs include actual costs to repair equipment and also other costs potentially incurred due to any increased system downtime which occurs as a result of pollution control system maintenance.

Fixed annual costs include plant overhead, taxes, insurance, and capital recovery charges. In the example shown, total plant overhead is calculated as the sum of 30 percent of direct labor plus 26 percent of all labor and maintenance materials. The OAQPS Control Cost Manual combines payroll and plant overhead into a single indirect cost. Consequently, for "study" estimates, it is sufficiently accurate to combine payroll and plant overhead into a single indirect cost. Total overhead is then calculated as 60 percent of the sum of all labor (operating, supervisory, and maintenance) plus maintenance materials.

Property taxes are a percentage of the fixed capital investment. Note that some jurisdictions exempt pollution control systems from property taxes. Ad valorem tax data are available from local governments. Annual insurance charges can be calculated by multiplying the insurance rate for the facility by the total capital costs. The typical values used to calculate taxes and insurance is four percent of the total capital investment if specific facility data are not readily available.

The annual costs previously discussed do not account for recovery of the capital cost incurred. The capital cost shown in Table B-2 is annualized using a capital recovery factor of 11.75 percent. When the capital recovery factor is multiplied by the total capital investment the resulting product represents the uniform end of year payment necessary to repay the investment in "n" years with an interest rate "i".

The formula for the capital recovery factor is:

$$CRF = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

where:

CPF = capital recovery factor

n = economic life of equipment

i = real interest rate

The economic life of a control system typically varies between 10 to 20 years and longer and should be determined consistent with data from EPA cost support documents and the IRS Class Life Asset Depreciation Range System.

From the example shown in Table B-2 the interest rate is 10 percent and the equipment life is 20 years. The resulting capital recovery factor is 11.75 percent. Also shown is interest on working capital, calculated as the product of interest rate and the working capital.

It is important to insure that the labor and materials costs of parts of the control system (such as catalyst beds, etc.) that must be replaced before the end of the useful life are subtracted from the total capital investment before it is multiplied by the capital recovery factor. Costs of these parts should be accounted for in the maintenance costs. To include the cost of those parts in the capital charges would be double counting. The interest rate used is a real interest rate (i.e., it does not consider inflation). The value used in most control costs analyses is 10 percent in keeping with current EPA guidelines and Office of Management and Budget recommendations for regulatory analyses.

It is also recommended that income tax considerations be excluded from cost analyses. This simplifies the analysis. Income taxes generally represent transfer payments from one segment of society to another and as such are not properly part of economic costs.

## III. OTHER COST ITEMS.

Lost production costs are not included in the cost estimate for a new or modified source. Other economic parameters (equipment life, cost of capital, etc.) should be consistent with estimates for other parts of the project.